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Application of Glass Properties Data to Forming Operations

I. Temperature Distribution in Glass and Mold During Forming

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ABSTRACT

This paper covers one phase of a series of studies now being made in the effort to obtain a better understanding of machine forming processes in terms of the basic properties of the glasses while they are being formed in the machines. Apparatus and techniques are described for obtaining (1) heat content of the glass shape at any stage in the forming cycle; (2) temperature cycles and gradients in mold parts; and (3) temperature distributions in glass during the forming of simple shapes. The data from typical experiments are analyzed. The properties of two commercial glasses are listed, and examples are given to show how specific heat and viscosity are applied, through use of temperature distribution measurements.

I. INTRODUCTION

Satisfactory manufacturing methods for making glass products can best be achieved by using the properties of the glass as a guide for the process needed. The ever increasing requirements in glass manufacturing make it necessary to replace cut and try practices by straightforward engineering methods wherever possible.

This paper describes research directed toward the application of glass property data to the commercial production of glass containers. Specifically, it covers that part of the process which starts with extraction of the glass gob or charge from the feeder or pot, followed by delivery to the machine in which it is shaped to the final form. The present paper covers one phase of a series of studies now being made in the effort to obtain a better understanding of machine forming processes in terms of the basic properties of the glasses while they are being formed in the machines. Future papers will describe other parts of the work now under investigation.

Examination of the glass literature shows that published information on the physics of forming has not been extensive. Principal among the sources that have come to the attention of the authors are: (a) Papers by Voorhees[1] and Coad Pryor[2], relating to the use of calorimetry for determining mean temperatures of hot glass objects; (b) The work of Solomin and Kitaigorodsky[3] and of Burch and Babcock[4] on relative cooling rates of colored and colorless glasses; (c) The several papers of Boow and Turner[5] on glass temperatures during hand-forming, semi-automatic and automatic forming of hollow-ware; (d) Theoretical and experimental work by Giegerich[6] on the heat balance between glass and mold parts; (e) The recent publication by Trier[7] on measurement of mold temperatures.

The ultimate object from an engineering viewpoint would be to know the following about the machine

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process for making glass containers: (a) The spatial and time distributions of temperature in both glass and mold metal throughout the forming cycle. (b) The stress acting at all points in the glass, at all stages of the cycle. (c) The effects of these forces and temperatures on the motion of the glass during forming, and upon the final strength, appearance, and other physical attributes of the finished product.

Since all properties of the glass, both mechanical and thermal, are highly temperature dependent, the first objective must be to form as clear a picture as possible of the temperature distributions in glass and mold metal, as functions of time during the forming cycle. Only after this has been done can an intelligent application of properties information be made to the process under consideration.

The following mechanical properties of glass are being used to determine the rate of motion of the glass, and the stress developed in it, as the ware is formed; viscosity, elasticity, surface tension, thermal expansion, and the impact, flexural, and tensile strengths.

The following thermal properties are being used to study the rate of heat removal from glass, and its temperature distribution at any instant during the process: thermal diffusivity, heat transfer coefficients at glass to metal interfaces, mass and volume specific heats, and density.

The thermal properties of metals being used in this work are density, specific heat, conductivity, and radiative properties.

The purposes of this introductory paper are: To describe briefly the hot glass facilities and experimental forming machine being used; To describe the apparatus and methods developed for making temperature distribution measurements during forming operations; To show, by means of typical experiments, how the data obtained by these methods are utilized; Finally to show how the properties of the glass are applied to the forming operation, through the use of the heat transfer and temperature distribution measurements.

II. APPARATUS FOR HEAT TRANSFER MEASUREMENTS

a. Experimental Forming Equipment

Although experiments on the fundamentals of forming may be performed on commercial operations or on machines in the development stage, it is usually not expedient to do so, either because of scheduling difficulties or the relative inflexibility of the machine operation. However, H. H. Holscher and co-workers, of this laboratory, made an extensive study of glass and mold temperatures on operating machines during the period 1939-1942. These data served to set the stage for relating glass properties with the forming process. While these early glass and mold temperature procedures were admittedly crude, they represented a necessary stage in the development of the presently reported procedures.

In order that basic forming studies may proceed without interruption, the feeder on one of this laboratory's furnaces has been provided for such work, and a small but versatile forming machine was built by Keith Conrad and others of this laboratory to perform the required

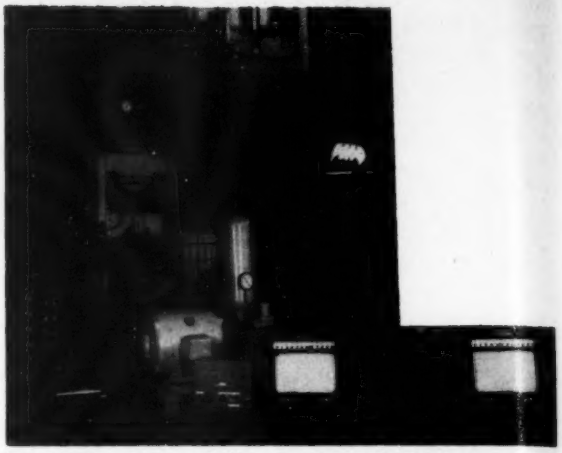


Fig. 1. Front view of the experimental forming machine, showing some of the associated instrumentation.

operations. See Figure 1. In the studies to be described here, the machine was used exclusively for pressing operations, but facilities are also available for the free blowing of simple parison shapes.

The experimental forming unit is powered by a hydraulic pump and accumulator capable of delivering oil at pressures variable from zero to 600 lbs. per sq. in. and at a rate of 50 gals. per min. at maximum pressure. The sump contains thermostatically-controlled heating elements and cooling coils to maintain the oil at a constant temperature of 120°F. This helps to ensure constancy of rate of motion of the machine parts. Individual pressure regulators and gauges are also used in the blank mold and plunger supply lines in order that the pressures and rates of travel of these parts may be varied as required by the experiment.

The machine is flow fed, and is controlled by a timing drum, which is rotated by a shaft and gear train connected to the drive of a Hartford feeder. Cams on the timing drum actuate a series of three-way valves and electric switches to produce the required series of actions. The timing drum arrangement has been so designed as to give almost unlimited flexibility to the number of forming actions that can be controlled. As presently used, the drum has enough cam slots to control a complete press and blow sequence, plus four spare slots, and provision has been made for the addition of a second timing drum at the end of the existing one, if required.

For the experiments to be described here, the machine performs a simple pressing operation similar to that used in the Miller Press and Blow Machine. The mold equipment used consists of a one piece blank mold, a plunger and split neckrings. The mold is supported in a cooling cage through which mold cooling air is directed against the sides and the bottom of the mold. This cage is fastened to a platform which is bolted to the top of the mold actuating piston. Application of hydraulic pressure to this piston raises the mold to the pressing position. When the pressure on the piston is released, the mold retracts under reverse piston action, and the weight of the assembly.

The split neckrings, which form the finish of the parison are held in a pair of hydraulically-actuated steel

jaws. These jaws are supported on a heavy cross-beam about twelve inches above the idle position of the blank mold. When positive pressure is applied to the jaws, they close the neckrings to form a circular mold for the parison finish. When the pressure is reversed, the neckrings open to release the parison. The bottom surface of the neckring arms provides a positive land for the top surface of the blank cage when the blank mold rises.

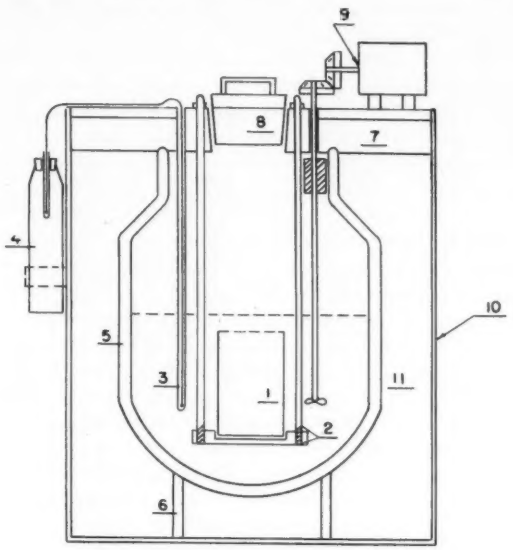
The plunger is held in an adapter which is bolted to the platform on the bottom end of the plunger piston. The adapter is provided with air channels so that cooling wind may be directed to the interior of the plunger and exhaust to a port in the adapter. The plunger is actuated by a hydraulic piston somewhat similar to that on the mold station. On application of positive pressure the plunger moves down through the neckring assembly to the end of the mold. If the mold contains glass, the plunger stops when the mold fills; if the mold is empty, the plunger adapter stops against the top surface of the neckring cross-beam. Reverse pressure is applied to the piston to retract the plunger.

A feature of the design that is especially helpful in exploratory work is the ability to use machine speeds that are sub-multiples of the feeder speed. It is possible, for example, to convert in a few minutes time from an operation at 15 feeder cuts and 15 pressing actions per minute to a slower operation of 7.5, or 5, pressing actions per minute. This is accomplished in two steps: (1) The gear train on the timing drum is changed to slow the machine to one-half, or one-third, of the initial rate. (2) An additional cam is placed on the drum, to actuate a pressure switch connected to the solenoid on a pneumatically-operated cullet chute under the orifice. When the mold is closed, the cullet chute is interposed between the feeder orifice and the gob delivery system, and the unwanted feeder cuts are directed to the cullet bin. When the mold opens, the added cam causes the cullet chute to retract and the gob is delivered to the mold in proper sequence. This system, in conjunction with the latitude in feeder speeds that are possible on one given set-up of the Hartford feeder, makes a wide range of machine cycles available without resorting to time-consuming changes of the feeder parts.

b. Calorimetry

The calorimeter used for heat content measurements in experimental forming operations is shown in Figure 2. Water is used as the heat exchange medium. The unit is rugged and portable, so that it may be placed adjacent to any machine without interference with production.

The sample basket (1) is a cylindrical cup, fabricated of 24-mesh stainless steel wire gauze. The size most commonly used will accommodate sample parisons or objects up to 3.5 inch diameter by 5 inches long. The wire mesh permits ready circulation of water about the sample. The basket support (2) is a copper ring platform, hung from two phenylite (a fabric-reinforced phenolic) rods which extend to the outside through holes in the cover (7). By lifting on these rods, the sample basket may be lifted to the mouth of the calorimeter for insertion of the sample. Water temperature changes are indicated by a thermopile consisting of six chromel-alumel thermocouples in series connection (3). The thermocouples are contained in glass protection tubes; the junction of each thermocouple is covered with mercury and the remainder of the tube is filled with paraffin. The tubes are located at different heights and angles around the basket, so as to obtain an average of temperatures at various points in the water. The ice junctions are located in a one-half pint Dewar flask (4), held in a clip on the side of the calorimeter.



WATER CALORIMETER

Fig. 2. Water calorimeter for measurement of heat contents in hot glass operations.

The calorimeter body proper is a twelve-liter Pyrex Dewar flask (5). It rests on a support ring of 20-gauge sheet metal (6), and the mouth of the flask is held in a circular notch milled in the bottom surface of the calorimeter top (7). The top consists of an inner cover of phenylite 2 inches thick and an outer cover of half-inch Transite (an asbestos-cement board). A sheet of polished 24-gauge stainless steel is cemented to the bottom side of the phenylite to reduce radiation losses. The removable top plug (8) is of the same construction as the rest of the cover. The hole and plug have a 10° taper to provide a snug fit and easy removal. A motor-driven stirrer (9) is mounted on top of the calorimeter. The stirrer and drive rod are connected by a phenylite bushing which serves as a heat block. The outer shell of the calorimeter (10) is of 16-gauge black-iron, approximately 14 inches diameter and 18 inches long. The space between the flask and shell is filled with glass fiber insulation (11).

The calibration of the calorimeter is based on a water volume of 6.400 liters at 75°F. ± 2°F. This volume fills the chamber to the approximate level indicated in Figure 2. Adjustment of water volume during use of the instrument is accomplished by means of a copper siphoning tube, which is inserted (with sample basket removed) such that it stands vertically with its tip resting on the center bottom of the chamber. A horizontal slot in the side of the tube causes the siphoning action to stop at the required water level.

The millivoltage output from the calorimeter thermopile is read to 0.001 millivolts by means of a Leeds and Northrup semi-precision potentiometer. In both calibration and operation, the initial water temperature is adjusted to room temperature, plus or minus 2°F. Originally, the instrument was calibrated by the method of mixtures; a platinum crucible containing a glass of known specific heat was heated to constant temperature and dropped into the sample basket. This was done at ten combinations of sample weight and sample temperatures in the forming range. A later calibration was made by a primary method, using 110-volt immersion heaters of different wattages to obtain a range of rates of heating equivalent to those obtained in the original calibration and in actual plant usage. The two methods agree closely and encompass a range of heat input from 60 BTU to 235 BTU. The calibration constant of our calorimeter is 0.0094 millivolts per BTU, at 60 BTU input, and decreases linearly to 0.0090 mv per BTU at 235 BTU.

Samples from operating machines are taken in a number of ways depending upon the shape of the sample. Gobs may be dropped directly into the calorimeter from the feeder, or transferred from the end of the delivery system with a Transite scoop. Parisons may be caught in a light metal ring when released from the neckrings; blown ware is usually caught on a flat Transite paddle. One attempts to establish a minimum of surface contact between the sample and the transfer tool and to accomplish the transfer in a minimum time. For the calorimeter measurements to be described, the time required for transfer was approximately two seconds. The calorimeter is kept closed except for the time required to insert the sample.

After the millivoltage corresponding to the water temperature change has been recorded, the fragments of the sample are recovered from the calorimeter, later to be dried and weighed. As a rule, from five to ten individual samples are taken to obtain an average heat content representative of the conditions of forming. Individual determinations are corrected to a final mixture temperature of 40°C (104°F.) in order that all results may be on a directly comparable basis. In the range of the above calibration (60 to 235 BTU), the estimated precision of a single measurement is 0.5 BTU. The average of five or more values can be expected to give a precision considerably less than 0.5 BTU, provided all samples have the same initial heat content. In actual practice, the samples exhibit individual variations, such that the precision of an average of 5 samples is usually in the range from 0.5 to 1.0 BTU.

c. Measurement of Mold Temperature

Temperatures in mold parts are measured by means of No. 28-gauge (wire diameter 0.012 inch) Chromel-Alumel thermocouples, percussion welded to the bottoms of No. 65 holes (diameter 0.035 inch) drilled in the required locations in blanks or plungers. Figure 3 shows the detail of a typical installation. Two holes are drilled into the mold body to the required depth, with approximately 3/16 inch between hole centers. Hole depths are measured to the nearest 0.001 inch before installation of thermocouples; this is done by use of a dissecting needle and a jeweler's pin-vise, mounted on a dial gauge. The thermocouple wire found most satisfactory is Leeds and Northrup 28-58-1, a duplex type. Each wire is enclosed in a silicone-bonded asbestos wrap, and the two conductors have a braided glass fiber sheath overall.

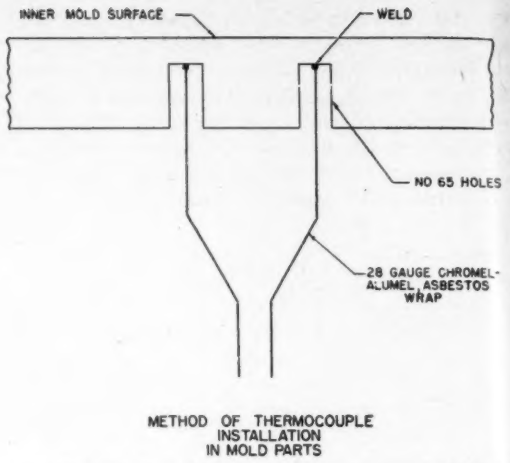
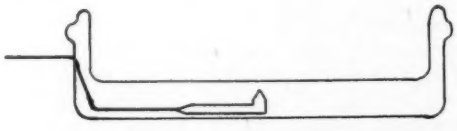


Fig. 3. Detail of method for installing percussion-welded thermocouples in mold parts.

The thermocouple wire is cut to the required length; two or three inches of the outer sheath are removed on one end, leaving the asbestos wrap intact on the individual wires, which are then slipped into the No. 65 holes and percussion welded to the bottoms of the holes. The welder consists essentially of a bank of condensers having a total capacitance of 1600 microfarads. The condenser bank is charged by a rectified 110-volt 60-cycle supply. One lead from the bank is attached to the mold and the other to the free end of the thermocouple lead. When sufficient charge has built up on the bank, it is discharged by touching the tip of the wire to the bottom of the hole, thus forming a weld at the point of contact. Two such welds constitute a chromel-mold metal-alumel junction in a virtually isothermal plane. Properly welded junctions will withstand tensile forces up to forty pounds, but are easily broken by flexing. It is, therefore, necessary to secure the leads to the mold wall by cementing or by a properly designed clip within one-half inch of the holes.

All of the mold temperature experiments to be described were performed in a set of simple mold parts designed particularly for heat transfer work. The parison (see Figure 6) is simply a flat circular disc, three inches in diameter, with a short sidewall and a finish to facilitate machine handling. The wide, flat base section of the mold is readily accessible for temperature measurements, and heat flow to the blank and plunger from the center section of the glass is virtually one-dimensional in character.



SECTION OF M-93 PARISON SHOWING THERMOCOUPLE LOCATION

Fig. 6. Section of parison produced in heat transfer mold equipment. A thermocouple is shown embedded in the base portion.

The blank mold is shown in Figure 4. The No. 65 holes for thermocouples are located on a half-inch circle about the center point of the base. The bottom of the mold is ⅜-inch thick, and provision is made for five thermocouples, varying in depths from 0.031 inch for No. 1 to 0.312 inch for No. 5, as indicated. The No. 55 (diameter 0.054 inch) holes on a 1¼-inch circle are stud holes for clamps to secure the thermocouple leads.

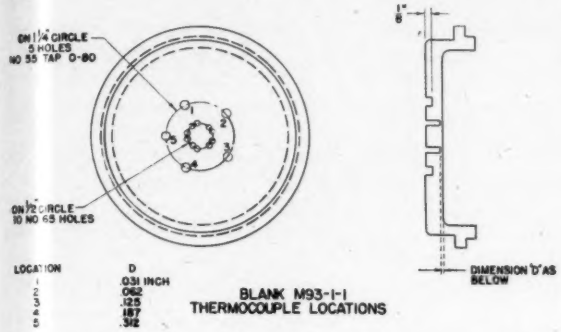


Fig. 4. Section of the blank mold for heat transfer studies, with hole locations on outside bottom for installation of thermocouples. Nominal hole depths are shown.

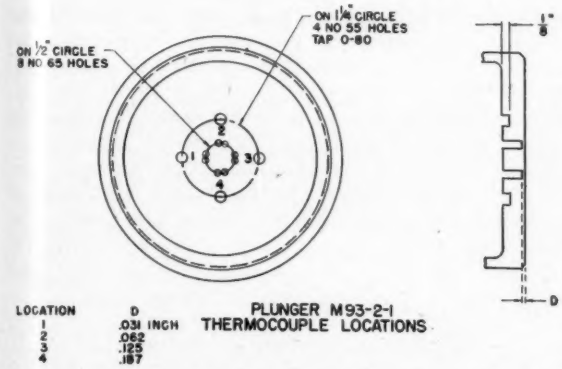


Fig. 5. Partial section of heat transfer plunger, showing thermocouple hole locations inside plunger. Nominal hole depths are shown.

Figure 5 is a partial section of the plunger, showing thermocouple locations in the pressing face. The face of the plunger is ¼-inch thick and contains four thermocouples. The lead wires are brought out through the cooling tube and emerge to open air through a packing gland in the cooling wind supply.

The chromel-alumel lead lines from the mold parts end at a terminal strip on the side of the forming machine. The temperature of the strip is taken for cold junction corrections. Copper conductors are used from this point to a selector switch located at the recorder equipment. The switch connects any one of the thermocouple circuits to a DC amplifier, whose output is supplied to one channel of a Sanborn 4-channel recorder. A Brown portable potentiometer is placed in the line, between the selector switch and the first amplifier. The potentiometer serves a dual purpose; it is used to supply a bucking voltage to the circuit while recording, and, on reversal of the terminals, provides a calibration scale for the recording system. For the types of experiments described here, the amplifier gains are adjusted to produce a full-scale deflection on the recorder from an input of approximately 4.0 millivolts. This sensitivity will record any mold temperature cycle not in excess of 150°F.

In operation, the molds are run without recording until steady cyclic temperatures are obtained at all locations. When this condition is secured, one of the thermocouples nearest the glass-metal interface (e.g., No. 1 in blank or plunger) is recorded, using sufficient bucking voltage so that the full temperature cycle is recorded. After five to ten cycles, the selector is switched to the next nearest thermocouple, the bucking voltage is reduced as necessary, and the recording process is repeated. Several such runs, including all thermocouples, are taken over the course of a day's operation, in order to average out minor shifts of mold temperature due to variations in initial glass temperature, cooling wind pressure, and the like.

Use of the system described provides a set of temperature-time curves representing the cyclic condition at graduated depths in the mold wall. By crossplotting from the temperature-time records, the temperature distribution across the mold at any given instant is obtained. There is, of course, some positive error in each temperature reading, due to the heat block in the vicinity of the holes, and the error increases as the distance from the glass-metal interface to the junction point decreases. However, the error is usually small since the holes are small, and are nearly filled by the thermocouple wires. Calculations show that in general the error from this source is approximately 10°F. if the distance from the interface to the junction is 0.025 inch. Since the least measured distance from the glass-metal interface is nominally 0.031 inch, the error caused by the presence of the junction will be 10°F. or less.

d. Measurement of Glass Temperatures

The mechanism of heat transfer in glass during the forming process is more complex than in any other stage of glass manufacture. The complexity is due primarily to the rapid drop in effective thermal diffusivity of glass as its temperature decreases [8], [9] and secondarily, to the discontinuities in radiative and conductive properties at the boundaries, i.e., at the glass-metal interfaces. With the present state of the theory of heat transfer, little of value can be done toward calculating the temperature distribution in glass as it cools in the mold. This has led to the conclusion that a major effort should be made to measure temperatures within glass and on its surface. The following is a description of a method devised for measuring glass temperature distribution in the base of the heat transfer parison described previously. In this method, a thermocouple is inserted in the blank mold cavity just prior to loading of the glass charge. The procedure is limited to simple flat-bottomed (or nearly flat) shapes, and each determination requires a new thermocouple.

The major problem was to devise a measuring system with sufficient speed of response to follow temperature changes in the glass; in particular, the system must respond to a change from room temperature to gob

temperature in as short an interval as possible. The thermocouple is, therefore, the limiting factor in the system. It must have a small mass to afford rapid response, but must have sufficient strength and rigidity to withstand the glass motions during pressing operations. The best wire we have found for this purpose is the same Chromel-Alumel duplex described previously. Individual thermocouples are made up from cut lengths about 18 inches long. The bared ends are twisted together and either flame-welded or arc-welded under oil, taking care to form a small bead. All of the excess twist is then taken out so that the bead is the only point of contact; finally, the bead is ground on a belt sander until the junction point is at least as small in diameter as the wire proper. Since the thermocouple remains in the parison after pressing, a quantity of thermocouples must be made up in advance for each experimental series.

To record the output from the thermocouple in glass, a Sanborn Oscillograph is used. Sufficient amplification is needed to produce full-scale response on the recorder from an amplifier input of 25 millivolts. Circuit lags in the instrumentation must be small compared to the thermal lags of the thermocouple, and the gain of the system should be as linear as possible. These requirements are well satisfied by use of the standard Sanborn Oscillograph Amplifier, preceded by either the Brush D. C. Model 913 as a pre-amplifier, or by a pre-amplifier section from the Sanborn 4-Channel Recorder.

The speed of the system has been tested by immersion of thermocouples in Cerrobase metal at 1500°F, and in glass at 2200°F. The thermocouples will reach the metal temperature in 0.5 seconds, and will attain the glass temperature in 0.9 seconds. Thus, it appears that the limiting factor is partially due to the glass itself, since the surrounding glass does not reheat as rapidly as metal after immersion of the cold thermocouple. In order to avoid this effect, the first reading on a temperature-time recording is always taken one second after beginning of the dwell period, i.e., after all motion of plunger and glass has stopped.

A notch ¼-inch wide and 1/16-inch deep is milled on the top edge of the blank mold, and a matching notch is provided on the top of the cooling cage. When a thermocouple is inserted in the mold during operation, the lead lies in this channel and, hence, is not cut by contact between the blank mold and the neckring assembly. A sliding clip is provided on the cage to hold the lead in position during upward motion of the blank.

The thermocouple is attached to a pair of copper conductors on the frame of the forming machine. These conductors lead to the amplifying and recording equipment. Again, a Brown potentiometer is used in series with the input line to provide calibration and counter potentials. The amplifier gain is adjusted to give full-scale deflection for an input of 25 millivolts and the thermocouples are opposed by a 25 mv counter voltage. Thus, the recorder scale covers all responses in the range from 25 to 50 millivolts, or from approximately 1100°F. to 2250°F. The temperature of the connection point at the machine between the thermocouple and the copper conductors is taken as the cold junction correction.

Before taking measurements, the machine is operated in glass to bring the molds to a stable operating condition. A thermocouple is bent to the approximate contour of the blank mold, with its tip bent upward to the approximate depth that is required in the measurement. This thermocouple is attached to the circuit, the circuit is checked for balance, and the counter voltage is cut in. Then the thermocouple is inserted into the blank mold, in the time interval between the opening of the mold and delivery of the next charge. After the gob falls on the thermocouple, the clip is tightened on the wire and the pressing action follows.

Immediately after the next opening of the blank, the machine is stopped. The parison is left attached to the circuit for about 5 seconds, to obtain a record of its reheat in air. Then the parison is detached and the machine is restarted. Usually two pressing actions are lost during the stoppage, and about five minutes of continuous operation is required to regain a stable condition. The procedure is then repeated with a new thermocouple.

Figure 6 shows the location of a thermocouple in the base section of a parison. It is not possible to locate thermocouples in the upper (plunger) half of the base section with any consistency. All data reported here are for thermocouples in the lower half (blank mold side) of the base section.

Parisons containing thermocouples are passed through a lehr and saved for measurements of thermocouple depths. The parisons are sectioned within ⅛-inch of the thermocouple tip and the distance from the weld to the glass-metal interface is measured by means of a traveling microscope. Although one can control the approximate depth to some extent by the amount of pre-bend given to the junction, a number of samples are required to ensure that the full range of possible depths has been covered. Due to this uncertainty, and to the inherent errors of measurement, about 30 individual recordings are needed to obtain a good statistical representation of the temperature distribution, under one set of operating conditions. The precision in the measurement of an individual thermocouple depth is approximately ±0.004 inch; the error in recording and reading the associated temperature-time curve is estimated to be ±25°F.

III. DESCRIPTION OF TYPICAL EXPERIMENTS

The experiments to be described here are examples selected from several laboratory investigations. They demonstrate the utility of calorimetry, and mold and glass temperature measurements, in the study of basic forming operations.

a. Calorimetry

1. Effect of Glass Weight on Quantity of Heat Removed in Pressing

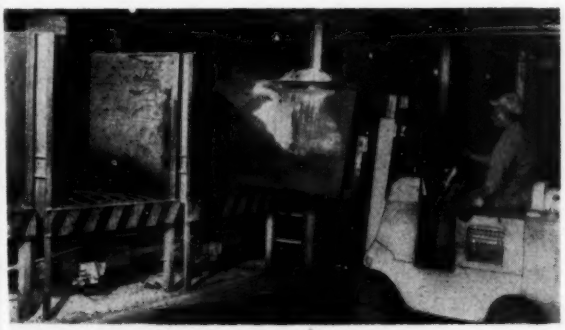
Cyclic variations in feeder temperature and glass level, and variations of mechanical actions in the feeder, will cause changes in the weight of the glass charge supplied to a flow operation. It is, therefore, of interest to determine the effect of weight of the glass charge upon the quantity of heat removed by the blank mold, other operating conditions remaining unchanged. With production types of molds the greatest weight change that can possibly be effected, and maintain a continuous production, is less than 10 per cent. In order to make observations under conditions that allowed a considerably greater

(*Continued on page* 144)

The self-dumping Roura hoppers Ball Brothers uses to collect cullet are stationed in a basement below the 21 forming machines. Three or four hoppers are assigned to each machine. Cullet is washed down a chute into the hoppers.

Self-Dumping Hoppers Cut Costs of Cullet Handling for Ball Brothers

Continual immersion of the molten glass in water helps to cool the glass and prevent it sticking to sides of the hopper. A worker occasionally stirs the cullet to hasten cooling.



At the cullet crusher the fork truck operator flips a handle on the hopper, which dumps and rights itself. Crushed glass is conveyed on a belt to the batching operation. Empty hopper is returned to chutes from forming machines.

By using leak-proof, self-dumping hoppers for the collection of cullet, Ball Brothers Company, Muncie, Ind., has solved two problems usually connected with the handling of this scrap glass. First, the hoppers can be moved quickly and easily by fork truck, thus eliminating slow, costly manual labor necessary with other types of containers. Secondly, they allow a cleaner operation than other methods and require little or no maintenance.

Ball has eighty Roura hoppers and all but a few are used for cullet handling. (Several are used for general plant maintenance.) They are stationed in a basement area under the firm's 21 container forming machines. Three or four hoppers are assigned to each machine.

When a jar or bottle fails to meet specifications, or when there is a machine change-over for a new job, the molten scrap glass is shunted into a chute. Water is introduced into the chute with the glass to wash it down to the hopper. Continual immersion of the glass in water serves to cool the glass and prevent it from sticking to the sides of the hopper.

When the hopper is full, water is drained off and a fork-lift truck carries the hopper to a cullet crusher. The operator lifts a handle on the hopper and it dumps itself, returning to an upright position when empty. Crushed glass is conveyed on a belt to the batching operation and reintroduced into the glass mix.

Of the several methods of cullet handling which Ball has tried, the hopper method has proved most efficient and least costly. Previous techniques included the use of wooden boxes, vats and steel barrels, but each of these methods was comparatively slow and required a great deal of manual labor. Only one man and a fork truck are needed to handle all the hoppers.

Application of Data . . .

(*Continued from page* 142)

change of weight, a series of tests were run on the heat transfer parison.

It was found that by proper selection of operating conditions, these molds could be operated continuously in any gob weight from 3.5 ounces to 6 ounces, without change of the cycle or cooling wind settings. The experimental machine was operated at a rate of four parisons per minute, with a 5-second dwell period. Blank and plunger cooling wind flow, and plunger pressing pressure were held at the same values for both glass weights. The optical temperature of the gob (measured by a Leeds and Northrup disappearing filament pyrometer) was maintained at 2080°F.

Starting at a gob weight of 3.5 ounces, calorimeter tests were made on five gobs, caught at the end of the delivery system. The molds were then warmed up to a steady operating condition, and calorimeter measurements were made on five 3.5-ounce parisons, taken during continuous operation. The gob weight was then increased to six ounces and the above series repeated for gobs and parisons, with no other change in operating conditions.

The results are given in Table I. At the time of delivery to the mold, the 6-ounce gob had a heat content of 208.5 BTU, almost 85 per cent greater than the 119.9 BTU contained in the 3.5 ounce gob. However, upon pressing the 6-ounce charge lost 49.1 BTU only 5 per cent more than the 46.6 BTU removed from the 3.5 ounce charge.

It is obvious that the six-ounce parison is at a higher average temperature, and has an entirely different temperature distribution than the 3.5 ounce parison. It has been observed that the portion of the mold wall nearest to glass operates at a higher temperature level when a larger amount of glass is pressed. However, the quantity of heat removed changes by a relatively small amount, and the outer surface of the mold (on which the cooling wind impinges) undergoes little change in temperature with the above change in weight. The reason for this apparent anomaly is not thoroughly understood.

2. Heat Removed in Stages of I.S. Operation

The following experiment shows the rate of heat removal by stages in an I.S. machine operation. The data were taken in a container plant, on two sections of an I.S.-8 machine manufacturing one-pound capacity wide-month food containers at a weight of 6.63 ounces; the data are shown in Table II.

The values shown for heat content of glass at the orifice were calculated from optical pyrometer readings of the maximum temperature of the charge, just as it emerges from the orifice. All other data are from calorimeter measurements. Gobs were caught on a heated Transite paddle, at the end of the delivery system, and dumped into the calorimeter. Parisons were caught in a wire ring when the operator held the blow mold open and released the parison at the blow mold position. Jars were taken in tongs when released at the takeout, prior to contact with the dead-plate. All values given in Table II are averages of five or more measurements.

In Section 1 of the I.S. machine, 20 per cent of the total heat dissipated in the forming operation was lost in extruding, shearing and delivering the charge to the blank mold; 42 per cent was removed during the pressing stage; and 38 per cent in the blow mold. For containers produced on Section 4, 21 per cent of the heat was dissipated in delivery of the charge, 38 per cent in pressing and 41 per cent in blowing. In both sections, it will be observed that the heat removed in pressing and blowing was about equally divided between the blank and the blow stations. Such equality is a characteristic of the conventional I.S. operation.

b. Mold Temperature

1. Temperature Cycles and Gradients in an Experimental Mold Set

The flow of heat in a glass mold section is a cyclic process, and once a stable operating condition has been

TABLE I

Effect of Glass Weight on Quantity of Heat Removed by Pressing (Type 2 Glass)

4 per minute—5 seconds dwell

Heat Content—B.T.U.							
3.5 Ounces of Glass				6.0 Ounces of Glass			
Gob		Parison		Gob		Parison	
Sample	BTU	Sample	BTU	Sample	BTU	Sample	BTU
1	120.2	6	73.9	11	207.7	16	158.2
2	120.1	7	73.3	12	209.1	17	160.2
3	119.9	8	72.8	13	208.6	18	158.4
4	120.2	9	73.8	14	208.4	19	160.8
5	119.3	10	72.9	15	208.6	20	159.3
Average	119.9 ± 0.4		73.3 ± 0.5		208.5 ± 0.5		159.4 ± 1.0

Heat removed in pressing 3.5 ounce parison: 119.9 — 73.3 = 46.6 BTU
Heat removed in pressing 6.0 ounce parison: 208.5 — 159.4 = 49.1 BTU

TABLE II

Heat Removed in I.S. Operation—One-pound Capacity Wide Mouth Jar
(Type 1 Glass)

9⅛ per section per minute—1.2 seconds dwell time

Section	Gob Optical Temperature-°F	BTU in 6.63 Ounces of Glass			
		Glass at Orifice*	Gob Delivered	Parison	Jar
1	2070	248.3	225.4	178.7	136.4
4	2080	249.6	225.4	182.1	134.4

*-Calculated from optical temperature

Section	BTU Loss by Stages		
	Delivery**	Pressing	Blowing
1	22.9	46.7	42.3
4	24.2	43.3	47.7

**-Total losses due to extruding, shearing and delivering gob to mold

attained, the temperature cycle will be repeated almost exactly for every charge that is dropped into the blank mold. The steady repetition of the heating and cooling cycle is an indication that a heat balance exists between the glass charge and the cooling medium. It is often instructive to examine the features of mold temperature curves in detail, since the mold gradients are a measure of the rate of heat removal from the charge, at any given instant in the cycle.

In the illustrations to be used here, the blank and plunger (Figures 4 and 5) were fabricated from mold iron, with 0.0015 inch of polished hard chromeplate on the outer surfaces. (The data are part of a study on the effects of reflecting vs. non-reflecting mold surfaces, which will comprise a separate paper in this series). The forming machine was operated at 2.2 seconds dwell time and 8.6 seconds total cycle. In reading from the original records, the instant at which the plunger contacts glass is taken as zero time. The time schedule for a cycle in the operation is as follows:

Gob in blank:	—1.1 seconds
Plunger contacts glass:	zero
Start of Dwell:	+0.1 seconds
End of Dwell:	+2.03 seconds
Next gob in blank:	+7.5 seconds

Temperature-time curves for the blank mold are shown in Figure 7. Note from the above schedule that the gob is loaded in the mold 1.1 seconds before plunger contact. The thermocouple nearest the mold surface, No. 1, is located 0.035 inch from the interface. The temperature at this point begins its upward swing at—1.0 seconds, or 0.1 seconds after the charge touches the blank. The cyclic lags at greater depths in the metal are: 0.25 seconds at 0.065 inch, 0.4 seconds at 0.138 inch, 0.5 seconds at 0.189 inch, and 0.9 seconds at 0.312 inch. Thus, the time lag is directly proportional to the distance from the glass-mold interface, within the limits of accuracy of the time measurements (±0.05 seconds). The mold bottom is 0.375 inch thick; on the above basis the cycle at the outer mold surface lags the cycle at the interface by 1.05 seconds.

The amplitudes of the temperature "waves" are, respectively: 100°F, at 0.035 inch; 81°F. at 0.068 inch; 50°F. at 0.138 inch; 38°F. at 0.189 inch; and 26°F. at 0.312 inch. The decay of the amplitude is exponential, obeying an equation of the general form

$$A = e^{md} + k$$

where

A is the wave amplitude
d is distance from the interface
e is the Naperian base
m and k are constants

This behavior is similar to the attenuation of the cycle from a sinusoidal heat source; it suggests that the initial heat input from the glass may be represented by a sine or cosine series. The wave form at the interface is thus a sine (or cosine) fundamental with many harmonics. As the wave traverses the mold metal the harmonics attenuate, and if the mold is thick enough, the wave approaches the simple sine-wave form. The progressive loss of harmonics is readily seen in the curves of Figure 7.

The temperature distribution across the mold thickness at any time in the cycle may be obtained by cross-plotting from Figure 7. Three such curves are given in Figure 8. Curve (1) depicts the distribution at the instant the glass charge contacts the mold, and hence, represents the condition at the beginning of a cycle. Curve (2) shows the sharp increase that has taken place in the metal nearest glass 0.5 seconds later; the outer portion of the mold has not yet been affected. Curve (3) is the distribution at the end of the dwell period, as the blank mold and plunger begin to separate. The temperature near the interface is at a maximum; the temperature at the outer surface is rising, but will not reach a maximum for at least 1.5 seconds after the end of dwell.

Time-temperature curves for the plunger are given in

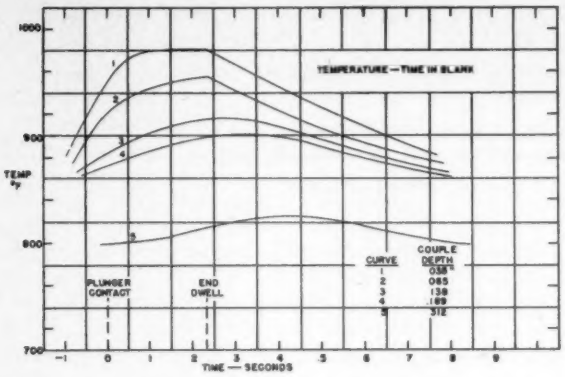


Fig. 7. Temperature cycles in a chrome-plated cast iron heat transfer blank mold. Glass charge 4 ounces.

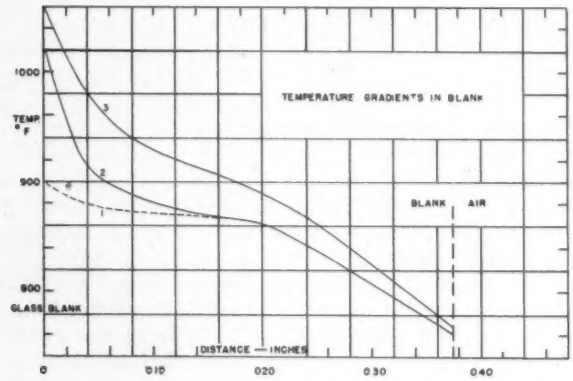


Fig. 8. Temperature gradients in blank mold: (1) At instant of contact between gob and blank; (2) 0.5 seconds after contact; (3) At end of the dwell period.

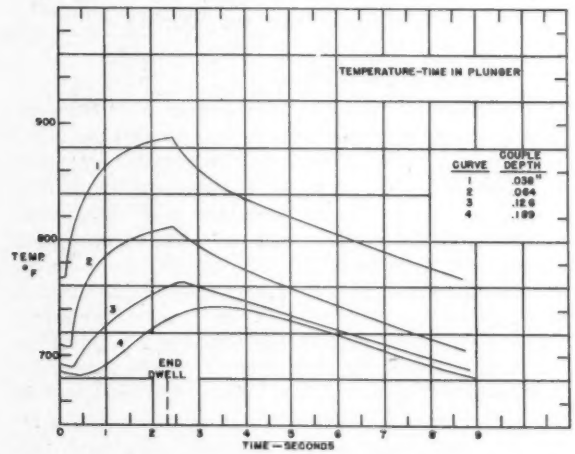


Fig. 9. Temperature cycles in chrome-plated cast iron heat transfer plunger. Glass charge 4 ounces.

Figure 9. Again the time of plunger contact with the glass is taken as zero. The plunger is in contact with glass for 2.2 seconds as compared to 3.3 seconds for the center portion of the blank. The heating time for the plunger is, therefore, shorter, and the cooling time longer than in the blank mold. This results in increased skew of the temperature wave toward zero time. In other features, temperature cycles in blank and plunger are much the same. Again one notes the cyclic lag, the decrement of wave amplitude, and the attenuation of harmonics, as the distance from the glass-metal interface increases.

Temperature distributions in the plunger bottom are shown in Figure 10. It will be seen that gradients in the plunger are much steeper than in the blank mold at all times during the cycle. This is due for the most part to the smaller thickness and volume of the plunger bottom, and in a lesser extent to the shorter contact time. The gradients are so great that extrapolations to surface temperatures are questionable; however, on the basis of the curves as drawn, the temperature at the interface cycles between approximately 930°F. and 1100°F., a difference of 170°F. If one plots the amplitudes of Figure 9 as a function of depth, the value obtained for the amplitude at the interface is 160°F. in good agreement with the above.

2. Effect of Dwell Time on Blank Mold Temperature

The study to be described here is one of a series of experiments to determine the effects of various controllable machine factors on mold temperature in a pressing operation. In this experiment, the factor varied was the dwell time, i.e., the total time that the plunger was at rest while in contact with the parison. Different dwell times were obtained by varying the position of the timing cam that actuated the descent of the plunger. The timing of the plunger retraction was not altered. All other machine variables (time of contact between glass and blank mold, the duration of the "inactive" period, plunger

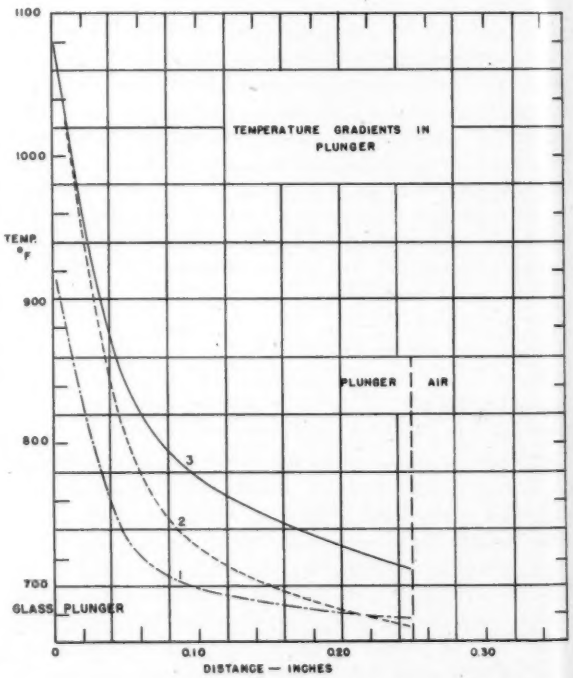


Fig. 10. Temperature gradients in plunger: (1) At instant of contact between plunger and glass; (2) 0.5 seconds after contact; (3) At end of the dwell period.

(*Continued on page* 148)

Controlling Conductivity in Silicates

• An urgent need for high-temperature electrical insulating materials has led the National Bureau of Standards to investigate methods of decreasing conduction in the basic glasses or frits used in vitreous ceramic coatings. Results of the study indicate the general type of composition yielding coatings of high resistance. A better understanding of the basic mechanisms controlling electrical conduction in glasses has also resulted from the project, which was sponsored by the Office of Ordnance Research, Department of the Army. S. W. Strauss, D. G. Moore, W. N. Harrison, and L. E. Richards of the Bureau's enameled metals laboratory conducted the investigation. The research was aimed indirectly at producing ceramic-coated parts having "built-in" electrical resistance superior to that of mica.

Conductivity in vitreous silicates at high temperatures is generally thought to be the result of the net unidirectional migration of alkali ions through the interstitial holes of the silicate framework. For an ion to migrate, its free energy of activation must be exceeded. That is, sufficient energy must be supplied to break the chemical bond between the alkali ion and the oxygen, and to move the ion to the next interstitial position. Thus, the conduction process may be pictured as a series of migrations of conducting ions from interstice to interstice. To obtain a better insight into the conduction mechanism, the Bureau made a detailed study of the conductivity of simple glass-forming systems, including a large number of ternary lead silicates and lithium sodium silicates.

Specimens were prepared for test by spraying a thin layer of silver paint onto each face. Stainless steel electrodes, located within the heating core of a furnace, were placed in contact with the specimen and the furnace was heated at the rate of about 10 deg C per minute. Voltage from a 200-v dry cell was applied during the entire heating period, polarity being reversed at least once each 20 deg C, and current was measured at 10 deg C intervals. The resistances of the glasses were determined from the current, voltage, and dimensions of the specimens for temperatures up to 500°C in some cases.

The observed variation in resistivity with change in composition indicates that conductivity depends on the nature of ions, being affected by such factors as their size and charge. Relationships between resistivity, composition, bonding energy, and experimental heat of activation of ternary lead silicates suggest that alkali ions may be the only conducting ions. Traces of alkali ions appear to decrease electrical resistivity, making purity of materials a main consideration in preparing alkali-free high-resistivity ceramic coatings. However, when the fusion point of the frit is very high, it may be necessary to add alkali ions to obtain workable coatings.

For lithium sodium silicates, a correlation was revealed between resistivity and composition, and between experimental heat of activation and composition. This finding indicates that substitution of two alkali ions for the same mole percent of either one leads to a more compact structure which decreases ionic migration. Thus, a composition containing approximately equimolar quantities of lithium oxide and sodium oxide has the most compact structure, and therefore the highest resistivity, in the ternary lithium sodium silicate system.

The investigation leaves some questions unanswered, such as whether or not hydrogen ions from water in the glass contribute to conduction. However, the study represents a definite contribution to the conduction theory and provides data that should be helpful in the design of glasses, glazes, and ceramic coatings of specified resistivities.

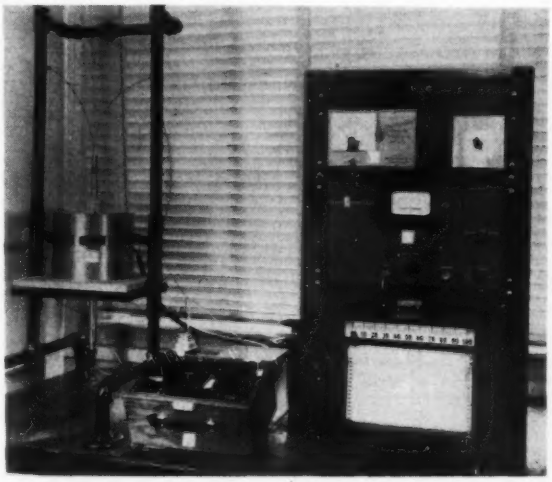


Fig. 1. Apparatus used at the National Bureau of Standards to measure electrical resistivity of ceramic coating materials at elevated temperatures. The furnace, left, houses two circular electrodes. The temperature of the top electrode, which contains an embedded thermocouple, is determined by a potentiometer, center. A second thermocouple, embedded in the furnace insulation, activates a control unit at the upper left of the console. A recording potentiometer at the bottom of the console used a dc preamplifier, immediately above the recorder, to graph the current passing through the specimen which is in contact with the electrodes. A shunt at the upper right of the cabinet extends the range of the preamplifier.

For further technical details see: Fundamental factors controlling electrical resistivity in vitreous ternary lead silicates, by S. W. Strauss, D. G. Moore, W. N. Harrison, and L. E. Richards, J. Research NBS 56, 135 (1956) RP2658; Electrical resistivity of vitreous ternary lithium sodium silicates, by S. W. Strauss, J. Research NBS 56, 183 (1956) RP 2665; Effect of temperature on the electrical resistivity of several ceramic and silicone type coatings, by S. W. Strauss, D. G. Moore, and L. E. Richards, ASTM sp. Tech. Publ. No. 153, 101-8 (1953).

Application of Data . . .

(*Continued from page* 146)

and blank mold cooling, and gob weight and temperature) were held constant throughout the experiment. The operation was carried out in heat transfer mold parts of 446 stainless steel, with a glass weight of 4 ounces and a pressing rate of 7.5 per minute. Dwell times of 1.95 seconds, 2.4 seconds, 2.8 seconds and 3.2 seconds were used, and temperatures were recorded at four depths in the base of the blank mold.

The temperatures reached by the mold at the peaks of the temperature cycles are plotted as a function of dwell time in Figure 11. These data show that the blank mold temperature increases linearly with dwell time, over the range measured. The effect is remarkably similar at all depth levels throughout the thickness of the mold. The average change, on the basis of these data, is 35°F. per one second change of the dwell time.

An average change of 35°F. per second was also found in the minima of these same cycles (data not shown); thus this figure may be regarded as the rate of shift of the operating level for the entire mold base, with change of dwell time.

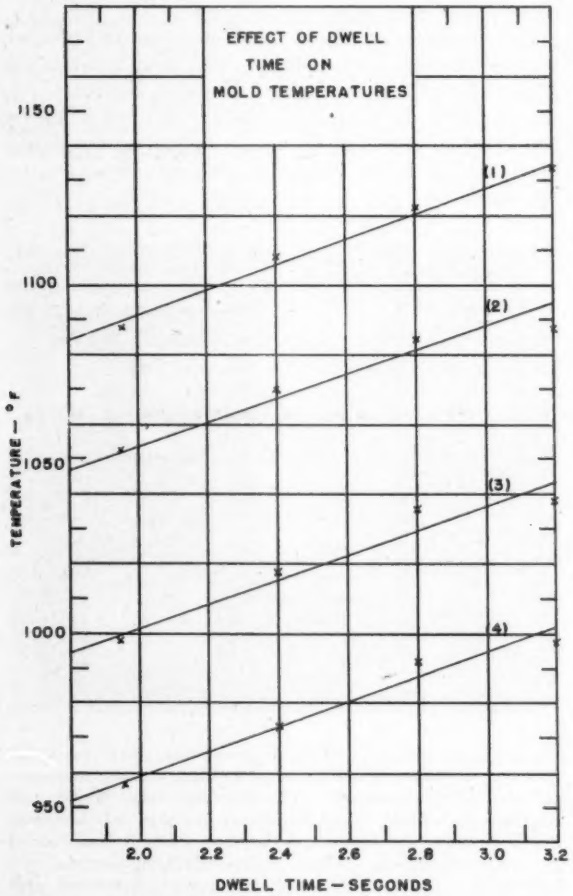


Fig. 11. Effect of Dwell time on temperature of a 446 stainless steel heat transfer blank mold. Glass charge 4 ounces. Temperatures are peak values, measured at the following distances from the glass-metal interface: Curve (1) 0.025″; (2) 0.069″; (3) 0.139″; (4) 0.193″.

The effects of all the controllable variables in an operation may be evaluated in exactly the same manner.

c. Glass Temperatures During Forming

1. Typical Temperature Distribution in a Simple Pressed Shape.

The method for obtaining glass temperatures in the base of the heat transfer parison was described in Section II (c) of this paper. The typical distributions to be discussed below were measured in the cast-iron chrome-plated mold set at four ounces glass weight, operating under the forming conditions described in Section III (b) on mold temperatures. In this operation the total cycle time was 8.6 seconds with a dwell time of 2.2 seconds. The optical temperature of the 4-ounce gob at the feeder was 2085°F.

In order to obtain the required data, a total of 35 individual temperature-time traces were recorded by successive insertion of thermocouples into the center of the mold cavity, after a steady cyclic operation had been attained. Six records were lost through poor placement of thermocouples or shorting of the conductors during the pressing action. The acceptable traces are records of the change of temperature with time at various depths in the base section. For reasons discussed previously, satisfactory records are not obtained in the "plunger half" of the glass thickness. The results, therefore, represent the temperature changes in the region from the blank mold interface to the center of the section. For the 4-ounce glass weight used in these experiments, the thickness of the base section was 0.28 inch.

After measuring the depths of the individual thermocouples by means of a suitable microscope, temperature distributions in the glass are obtained at various times in the cycle by cross-plotting from the temperature-time traces. The temperature distribution for the above forming conditions, at the end of the dwell period (i.e., at the instant the plunger retracts), is shown in Figure 12. The points are typical of the spread of the data obtained in this type of measurement, and further demonstrate what part of the parison section is covered by the experiment. It is of interest to note that the center, or maximum, temperature is approximately 1950°F., at the end of the pressing period, and that the extrapolated surface temperature is about 1350°F. Since the gradient is quite steep near the surface, there is, of course, considerable doubt about the latter value. At present it is not possible to obtain acceptable records at distances less than 0.006 to 0.008 inch from the glass-to-metal surface. Research is in progress on radiation pyrometers for measurement of near-surface temperatures from small areas of glass, with sufficiently rapid response to be useful on high-speed operations.

The curve through the point configuration of Figure 12 was fitted by visual means. In general it has been found that such temperature distributions in glass at fixed times in the dwell cycle are well represented by a relation of the type.

$$T = A\text{-}Be^{-kd}$$

where

T = the temperature at any distance d between surface and center.

A, B and k are constants

d = distance from surface to center, taking x = O at the surface.

This form may be fitted to the data by statistical means, but such procedure does not seem warranted until we better understand the physical nature of constants A, B and k.

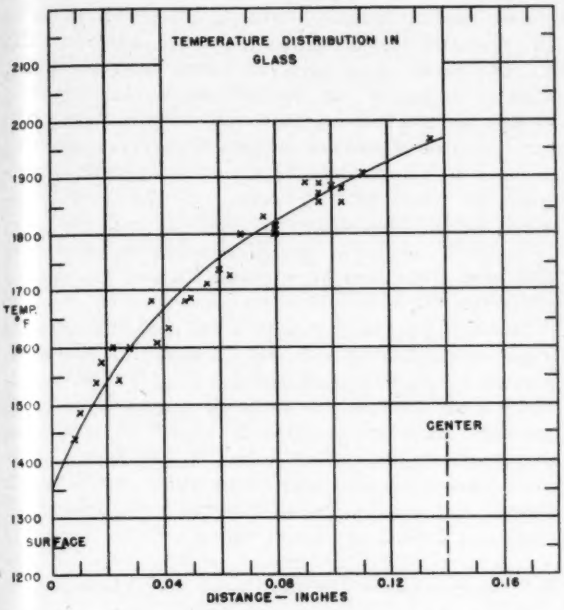


Fig. 12. Temperature distribution in base of heat transfer parison at end of 2.2 second dwell period. Parison formed in chrome-plated cast-iron mold. Glass charge 4 ounces.

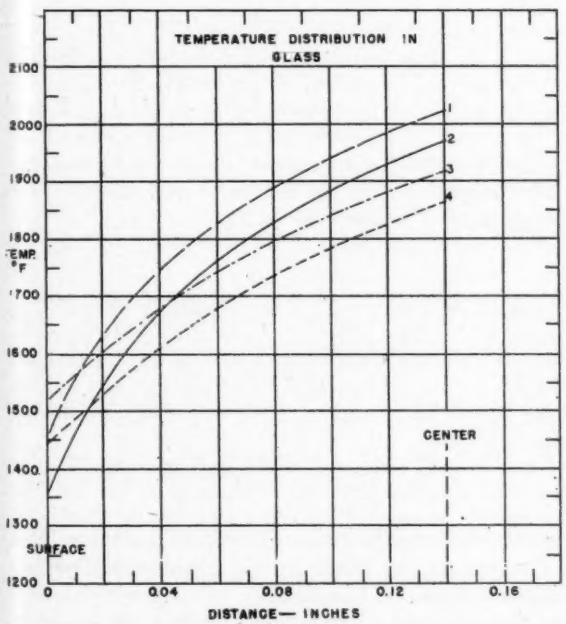


Fig. 13. Temperature distributions in base of heat transfer parison at various times. (1) One second after start of dwell; (2) At end of dwell period (same curve as Figure 12); (3) One second after end of dwell; (4) Three seconds after end of dwell.

The changes of the temperature distribution in the parison, during and after the pressing period, are shown in Figure 13. Curve number (1) shows the temperature 1.0 seconds after the plunger had reached the dwell position. Note that the surface has cooled to approximately 1470°F.; the center glass, at 2025°F. has hardly begun to cool, being only 60°F. below the originally observed gob optical temperature. Curve (2) is the distribution at 2.2 seconds, the end of the pressing period. This curve, the same as in Figure 12 is repeated here for comparison. Throughout most of the depth curves (1) and (2) are nearly parallel; this indicates that the rate of cooling is nearly uniform from surface to center during the period from 1.0 seconds to the end of the dwell period.

Curve (3) shows the distribution 1.0 seconds after the end of dwell, i.e., after the glass is released from the mold. The surface temperature has increased by more than 150°F., while the center temperature has decreased by about 50°F. The phenomenon known to the industry as "reheat" is thus quite evident. The average temperature of the glass section (as determined from the areas under curves (2) and (3)) decreased by approximately 20°F. during the first second of reheat.

Under the forming conditions given, the distribution at one second after pressing represents the approximate maximum of the reheating effect. Thereafter, the surface begins to cool again and the rate of cooling is fairly uniform throughout the depth of the section. Thus curve (4), depicting the temperature distribution three seconds after the end of dwell, is nearly parallel to curve (3) and averages approximately 50°F. lower in temperature. However, even though the average temperature of the mass of glass has decreased 70°F. in the three seconds following the dwell period, the surface is still approximately 75°F. higher than at the end of dwell. The importance of the time of reheat in determining the blowing properties of a parison is readily apparent.

IV. APPLICATION OF PROPERTIES DATA

a. Properties of a Typical Container Glass

Reference was made in the Introduction to the several thermal and mechanical properties of glass that apply to the forming process. In order to demonstrate the application of such properties to forming studies, data for two properties (specific heat and viscosity) will be given for typical container glasses, and these data will be applied to the results from some of the experiments on glass temperatures and heat contents previously described in Section III.

Specific heat data for a typical soda-lime container glass are shown in Table III. Although two different glass compositions were used in the forming experiments, the data of Table III are applicable to either type. Specific heat is not sensitive to composition changes in the relatively limited range of soda-lime container glasses.

The experimental determinations were made by the method of mixtures; hence the mean specific heats (Cm values) were directly determined. The true specific heats (C values) were calculated from the functional relationship found between Cm and temperature. Over the temperature range from 980°F. to 2200°F. the mean

TABLE III

Specific Heat (Heat Capacity)

Data For Typical Soda-Lime Container Glasses
(Types 1 and 2)

Temperature		BTU per lb. per °F, or Cal. per Gm. per °C	
		Mean	True
°F	°C	Cm	C
1000	538	.250	.319
1200	649	.264	.334
1400	760	.276	.346
1600	871	.286	.357
1800	982	.295	.366
2000	1093	.303	.375
2200	1204	.310*	.382*

*-(Extrapolated)

TABLE IV

Viscosity Data For Two Typical
Soda-Lime Container Glasses

	Degrees F.	
Log_{10} Viscosity	Type 1	Type 2
2	2615	2645
3	2170	2165
4	1880	1855
5	1680	1640
6	1530	1485
7	1420	1365
7.65 (Fiber Softening Point)	1365	1305
8	1333	1271
9	1242	1195
10	1176	1134
11	1125	1079
12	1080	1031
13	1039	992
14	1003	955
15	970	924

TABLE V

Glass Compositions

	Type 1	Type 2
SiO_2	71.24	70.80
Al_2O_3	1.47	1.82
CaO	10.81	6.20
MgO	2.92	4.18
Na_2O	12.48	15.80
K_2O	0.39	0.42
BaO	0.69	0.78

specific heat of soda-lime glass obeys the classical relation

$$Cm = A + B \text{ Log } T,$$

where

Cm = mean specific heat
T = temperature
A and B are constants

Viscosity data for the two typical soda-lime container glasses used in these experiments are shown in Table IV. Chemical analyses of the glasses are shown in Table V. The values given cover the range from 10^2 poises (Log_{10} viscosity = 2) to 10^{15} poises (Log viscosity = 15), and are from measurements taken in this laboratory. Viscosities in the range log 2 to log 5 are measured in either a falling sphere or a rotating cylinder viscometer; the fiber softening point (log 7.65) is determined by the fiber elongation method; and viscosities at temperatures below the fiber softening point (log 7.65) are determined by a modification of the method of Norton[10].

The glass designated as Type 1 was used in the experiments on quantity of heat removed in an I.S. operation, data for which were given in Table II. All other experiments were done on the experimental machine, using the glass designated as Type 2. It will be seen from comparison of the data in Table IV that Type 1 glass has a steeper viscosity-temperature curve than Type 2. Type 1 is, therefore, characterized as a "faster-setting" glass, and Type 2 as "slower-setting".[4]

b. Average Glass Temperatures and Viscosities

The average temperature of a glass object at any stage of the operation may be calculated from the heat content by use of the relation

$$Q = Cm \cdot m \cdot \triangle T$$

where

Q = quantity of heat, BTU
Cm = mean specific heat, BTU per lb.-°F
m = weight of the sample, lbs.
$\triangle T$ = difference between initial and final temperatures of sample, °F

In our method of calorimetry, the final corrected mixture temperature is 104°F., hence the average glass temperature T is given by

$$T = \frac{Q}{Cm \cdot m} + 104$$

Since Cm varies with T as previously shown, it is possible to make a plot of T as a function of Q/m, covering the forming range of temperatures and all expected values of Q/m. The average temperature of any calorimeter sample of container glass may be read directly from the plot.

In Table II were shown the heat contents of gobs, parisons and jars from two sections of an I.S. machine producing one-pound capacity wide-mouth food containers. The average temperatures corresponding to these heat contents, calculated by the above procedure, are shown in Table VI. Also shown are the average viscosities of Type 1 glass corresponding to these temperatures. The average temperature of the glass charge decreases by approximately 300°F. in each stage of the operation. The actual viscosities at each stage are, approximately: Gob, 6 x 10^3 poises; parison 2.5 x 10^5 poises; and jar,

TABLE VI

Thermal Data For I.S. Operation—One-pound Capacity Wide-Mouth Container

6.63 Ounces of Type 1 Glass

	Sample	BTU	Average Temp. °F	Average Log_{10} Viscosity
Section 1	Gob Delivered	225.4	1925	3.8
	Parison	178.7	1610	5.4
	Jar	136.4	1320	8.1
Section 4	Gob Delivered	225.4	1925	3.8
	Parison	182.1	1635	5.3
	Jar	134.4	1305	8.3

TABLE VII

Thermal Data For Experimental Press Operation—M93 Parison Effect of Glass Weight

Type 2 Glass

Glass Wt. Oz.	Sample	BTU	Average Temp. °F	Average Log_{10} Viscosity
6.0	Gob Delivered	208.5	1950	3.6
	Parison	159.4	1590	5.3
3.5	Gob Delivered	119.9	1930	3.7
	Parison	73.3	1340	7.3

2×10^8 poises. Thus, the viscosity increases by a factor of approximately 40 in the pressing station and by a factor of 800 in the blowing operation.

Table I showed the effect of a radical change of glass weight on the heat content of parisons produced in the heat transfer mold equipment. Calculated average glass temperatures and viscosities corresponding to these heat contents are shown in Table VII. The average temperature of a 6-oz. glass weight decreased by approximately 350°F. during pressing; a 3.5 oz. weight, produced with exactly the same forming cycle and cooling wind conditions, decreased by approximately 600°F. For 6 ounces weight, the pressing operation increased the average viscosity by a factor of 50; for 3.5 ounces, the factor is 4000.

Since large temperature differences exist between the surface glass and the center, immediately after any phase of forming, average values describe the expected behavior in only a very general way. The motion of glass in subsequent operations is largely determined by the viscosity distribution in the colder outer layer, or "enamel". The characteristics of these distributions in hot glass will be discussed in the next section.

c. Viscosity Profiles in Glass During Forming and Reheat

In the discussion of temperature gradients in formed glass, curves were given for the temperature distributions in the base of the heat transfer parison, at times during and immediately following the pressing period (See Figure 13). Since these experiments were performed with glass Type 2, it is a simple matter to apply the appropriate viscosity data to these temperature distributions. The result is shown in Figure 14.

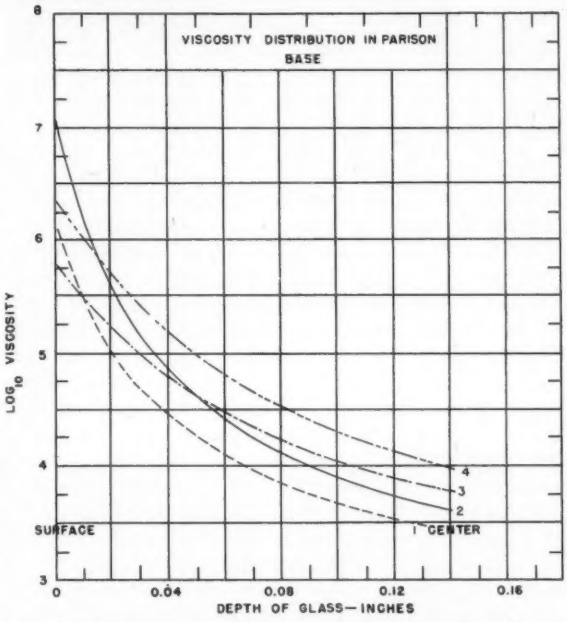


Fig. 14. Viscosity profiles in base of heat transfer parison at various times. (1) One second after start of dwell; (2) At end of dwell period; (3) One second after end of dwell; (4) Three seconds after end of dwell.

It is readily apparent that the mobility of the parison

(*Continued on page* 161)

SHARP RECEIVES TOLEDO AWARD

The 1957 Toledo Glass and Ceramic Award was presented formally to Dr. Donald E. Sharp, vice chairman of the technical policy committee of Libbey-Owens-Ford Glass Company, at a dinner sponsored by the Northwestern Ohio Section of the American Ceramic Society in the Toledo club Jan. 21, 1957. Many tributes from American and European scientists and glassmen were read at the meeting.

The award is a lead glass vase 11 inches in height, made by craftsmen of the United States Glass Co., Tiffin, Ohio, to a design prepared by Edwin W. Fuerst, Hartford, Conn., with Blake-More Godwin, director of the Toledo Museum of Art, as consultant.

The 1957 Toledo Award is presented to Donald E. Sharp by J. C. Coleman. Looking on are James Bailey, far left, and Ralph K. Day.

The citation as read by J. C. Coleman, chairman of the award committee, in presenting the vase, was as follows: "Donald E. Sharp, for your contributions to the science and technology of glass which range over the entire field, for your many outstanding papers and patents, for your work on the International Commission on Glass where you have greatly advanced the cooperative efforts of all the glass-making countries, for your fine personal qualities which have made you a leader in the ceramic field, the Northwestern Ohio Section of the American Society presents you with this, the 1957 Toledo Glass and Ceramic Award."

James Bailey, of the Plax Corp., Chicago, a former partner in the firm of Bailey & Sharp, at Hamburg, N. Y., paid personal tribute to Dr. Sharp and presented an outline of his life and accomplishments.

He also outlined many of the contributions made to glass technology and especially in the field of optical glass for the United States in World War I.

A surprise presentation was made by Dr. Howard R. Lillie, of Corning Glass Works. As a remembrance some of Dr. Sharp's former associates at Corning Glass had sent to him a ribbon-tied, faded data book, dated Nov. 23, 1915, taken from the Corning research files. "Meaningless as the figures are in this ancient and primitive data book, you wrote them, and we present them as an early milestone in your career," said Dr. Lillie.

Dr. Francis Flint, of Hazel-Atlas Glass Co., Wheeling, W. Va., a former recipient of the Toledo award, said "no one ever achieved success without using all the energy he had—Don did that." He also praised his interest in the humanities.

Karl Schwartzwalder, Flint, Mich., president of the American Ceramic Society on behalf of the society added greetings from the membership to Dr. Sharp. "Recognition underlies all human relations," he said. "It inspires others and breeds achievement. Recognition twice blesses —him who gives and him who receives."

In responding to the many tributes to his life and achievements, Dr. Sharp pointed out that there was no such recognized term as "glass technology" when he began as a summer vacation worker at the Corning Glass Works in Corning, N. Y.

"During my years in the glass industry it has been my privilege to serve as an assistant to or an associate of many outstanding men—Dr. E. C. Sullivan and Dr. W. C. Taylor, while I was serving as assistant to Dr. J. T. Littleton at Corning; Dr. G. W. Morey, James Bailey, Dr. J. C. Hostetter, and Virgil Mulholland.

"I was exposed to an ever-widening circle of great men in glass technology—men who guided me. To them I owe much. It is in that spirit that I accept this award tonight."

Dr. Samuel R. Scholes, professor emeritus of the New York State College of Ceramics at Alfred University, outlined some of the advantages of "Careers in Glass and Ceramics."

He declared it would cost some money to invest in youth but it will cost a lot more to withhold the necessary training, scholarship aid and fellowships for graduate study.

"It is enough to say that, although glass and ceramics are old, the young profession of silicate technology has made tremendous changes, affecting the welfare of all the people, in the brief decades of its activity thus far."

Dr. Scholes said that the public must be made to understand that the arts and sciences of the silicate industries are fundamental and essential to all the arts and sciences.

While the industries and research laboratories desire several hundred trained technologists in ceramics and glass, American colleges are turning out a few score annually. Dr. Scholes urged the group to enlist the interest of boys at an early age, aid in improvement of secondary school education, promote early industrial indoctrination such as employing youths for summer vacation work, and then all must help to make the glass and ceramics story more exciting. He said that graduate study for top men becomes a necessity and it should have both breadth and depth.

"Industry must generously provide more and more fellowships for advanced study," declared Dr. Scholes. "This investment in youth may be one of the most important steps that industry may now take, toward providing for the secure future of glass and ceramics."

The speaker referred to Dr. Sharp, honored with the Toledo award, as one who was encouraged as a young boy in vacation work to enter the field of glass technology.

Dr. Ralph K. Day, president of the host section, was toastmaster. He introduced several other officers of the American Ceramic Society and distinguished visitors at the dinner.

Inventions and Inventors

Annealing and Tempering

Toughening Ophthalmic Lenses. Patent No. 2,762,166. Filed May 11, 1953. Issued Sept. 11, 1956. Three sheets of drawings; none reproduced. Assigned to Temp-R-Lens, Inc., by Bruce R. Vent.

The invention provides a means of toughening ophthalmic lenses of any color, kind, size, shape, power or thickness, including bifocal, multifocal or single vision lenses, to render them more resistant to breakage.

An example of the procedure is as follows: A spectacle lens, corrected for vision and made of ordinary spectacle crown glass, is uniformly heated in a temperature controlled oven for three minutes at a temperature 1150° F. After the heating period the heated lens is removed from the oven and substantially centrally supported between two oppositely disposed, vertically positioned pointed carbon or graphite rods, having a rounded pointed portion of 1 mm. diameter and allowed to otherwise cool naturally in its supported position. It is preferred to dispose the heated lens between two conducting points but, if desired, one face of the lens may be cooled more rapidly than the other face through the medium of one conducting point. If desired, heat conducting elements having different coefficients of heat conductivity may be employed.

There were 31 claims and 18 references cited in this patent.

Feeding and Forming

Bottle Forming Machine. Patent No. 2,757,484. Filed August 5, 1946. Issued August 7, 1956. Twelve pages drawings; none reproduced. Assigned one half to Henry C. Daubenspeck, by Samuel E. Winder.

The present invention relates to a novel bottle forming machine. The machine comprises a mold, a mold head engagement therewith and fluid flow passages in the mold. The mold head comprises separable sections for finish forming. The finish forming elements are movably supported on each mold section, the fluid flow passages extending by separate routes both to the inner and outer ends of the elements for communication with the mold cavity, so that a vacuum may be drawn onto the glassware immediately beyond each end of the finish, without the necessity for extension through the mold cavity.

The invention provides for faster production of better ware, with less complication than was heretofore necessary. It also enables the manufacture of ware to be supervised by one man.

There were 25 claims and 29 references cited in this patent.

Safety Glass Construction. Patent No. 2,758,042. Filed Dec. 9, 1952. Issued August 7, 1956. One page of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company, by Richard F. Raymond.

As conventional safety glass units are exposed to severe temperature variations involving low temperatures, the vinyl interlayer, having a higher coefficient of expansion than the glass, tends to contract more rapidly than the pressure plate. This difference in contraction causes the glass to be stressed as the plastic interlayer tends to curl away from the extended portion of the pressure plate, thereby resulting in chips formed on the glass surface. This tendency to chip is known in the art as "cold chipping."

It has been discovered that by placing a reinforcing frame of suitable width and thickness of a material having a coefficient of expansion substantially equal to that of glass, such as aluminum, steel, or glass about the periphery of the cover plate, that it will compensate for the unbalanced condition of the cover plate and minimize cold chipping of this so-called "offset area" of the pressure plate. In other words, by attaching a rigid reinforcing frame to the plastic on or adjacent the surface opposite the surface attached to the expansion of the pressure plate, the desired balance is obtained.

There were 10 claims and the following references cited in this patent. 2,293,656, McClain, Aug. 18, 1942; 2,356,878, Painter, Aug. 29, 1944; 2,398,886, Drake, Apr. 23, 1946; 2,576,392, Downes, Nov. 27, 1951; 2,650,890, Bledsoe, Sept. 1, 1953 and 2,679,467, Sherts, May 25, 1954.

Mold For Shaping Glass Sheets. Patent No. 2,758,422. Filed July 30, 1949. Issued August 14, 1956. One page drawing; none reproduced. Assigned to Libbey-Owens-Ford Glass Company, by Joseph E. Jendrisak.

If certain precautions are taken, glass sheets that have been ground and polished while flat may be curved to correspond to the contour of a vehicle body without losing the optical qualities required for good vision. Of these precautions it is necessary, in particular, to minimize the local stresses in the glass sheets during the bending operation.

According to the invention a substantially solid guide plate is attached to the mold or mold framework in position to extend beyond the end of the shaping surface as a continuation of that surface. In the construction of the mold itself, the guide plate is preferably attached before the shaping surface is machined to final form; the same machine that contours the shaping surface also contours the guide plate thus automatically insuring that the guide plate is a smooth continuation of the shaping surface. The guide plate is designed and its contour arranged according to the outline of the glass sheet to be bent, so that full contact between the sharp edge of the glass sheet and the guide plate is maintained throughout the travel of the edge of the glass sheet as the sheet bends to final form. When more than one guide plate is employed, particularly when guide plates are located at opposite ends of a horizontally positioned glass sheet it is desirable to provide interconnected fingers operating in slots in the guide plates to make sure that both ends of the glass sheet move equal amounts as the glass sheet settles onto the mold. Without such fingers, or bar and finger combinations, one end of the glass sheet is apt

to stick on its guide plate with the result that the other end moves too far and the glass sheet does not settle into proper position on the mold.

There were six claims and the following references were cited in this patent. 280,143, De Voursney, June 26, 1883; 1,999,558, Black, Apr. 30, 1935; 2,003,383, Miller, June 4, 1935; 2,452,488, Paddock et al., Oct. 26, 1948 and 2,554,572, Jendrisak, May 29, 1951.

Furnaces

Heating Of Electric Furnaces. Patent No. 2,761,890. Filed March 16, 1953. Issued September 4, 1956. One page drawing; none reproduced. Assigned to Societe Anonyme des Manufactures des Glaces et Produits Chimiques de Saint Gobain, Chauny & Cirey, by Pierre H. C. La Burthe.

The present invention concerns an arrangement for heating electrical furnaces by Joule effect and more especially glass furnaces.

It consists in using in a furnace, fed by polyphase currents and for each of the alternative components of the polyphase system, a voltage which may be variable and in using between two special points of the furnace the resulting voltage from the composition of those variable voltages.

The furnace is supplied with a plurality of phases, each of which is independently variable, and in which the circuit is not completely closed by electrical connections but in which a gap is left, in the part of the electrical circuit submerged in the melt, between two electrodes of adjacent phases; through this gap a current may be made to flow from phase to phase. The leads and electrodes thus arranged produce a supplementary heated zone in a part of a furnace that would not be directly traversed by the primary current of any one phase, great flexibility is imparted to the heating of furnaces, and powers of different magnitude may be used in different phases without risk of damaging the transformer by short cut current built up through the plurality of phases.

In a disposition like that, when two electrodes, belonging to two adjacent phases, are next to each other in the bath, it is favorable to connect them, so that the two current intensities will differ in phase by the same angle $\frac{2\pi}{n}$ and the electric load per square unit of the electrodes will, thus, be smaller than if the phases were completely independent. n is the total number of phases.

There were 15 claims and 14 references cited in this patent.

Chute For Conveying Molten Glass. Patent No. 2,758,421. Filed April 2, 1952. Issued August 14, 1956. One page drawing; none reproduced. Assigned to Owens-Illinois Glass Company, by Robert M. Smith.

This invention relates to the manufacture of glass articles from charges of molten glass and more particularly to apparatus for conveying molten glass.

It has been determined that a satisfactory coating for chutes should have the following requirements. First, the frictional drag must be reduced to a minimum so that the travel of the gob is fast and constant, and the shape of the gob is not altered. Second, the coating must be hard and abrasion resistant in order not to contaminate the surface of the gob and in order not to be worn off the chute rapidly. Third, the coating must be resistant to heat. Fourth, the coating must be resistant to oil and water which are inherently present in the vicinity of the apparatus.

A coating having the desired properties comprises a phenolic resin and a filler such as graphite. The composition of the ingredients may be varied within wide limits to provide the exact results desired. For example, it has been found that a satisfactory coating will have the composition: 60 per cent phenolic resin, 40 per cent graphite. However the desired results can be obtained within the following limits: 20-95 per cent phenolic resin, 5-80 per cent graphite. If the amount of phenolic resin is increased the wearing properties of the coating are increased but the speed of travel of the gob is decreased; whereas, if the amount of graphite is increased, the wearing properties of the coating are decreased and the speed of travel of the gob is increased.

There were four claims and the following references were cited in this patent. 1,199,108, Peiler, Sept. 26, 1916; 2,106,545, Bates, Jan. 25, 1938; 2,581,301, Saywell, Jan. 1, 1952; 270,271, Great Britain, 1928 and 654,275, Great Britain, June 13, 1951.

Glass Wool and Fiber

Increasing Heat Resistance of Glass Fiber Wicks. Patent No. 2,762,168. Filed April 19, 1952. Issued September 11, 1956. No sheets of drawings. Assigned to The Coleman Company, Inc., by John E. McCutchen.

A novel process for treating glass fiber wicks is given. A bundle of glass fibers is subjected to capillary attraction by a solution containing a soluble salt decomposable into a refractory coating. The decomposed refractory coating which coats the fibers in a uniform manner tends to increase the refractoriness to a great extent.

There are eight claims and no references cited in this patent.

Laminated Fibrous Glass Material. Patent No. 2,762,735. Filed June 16, 1955. Issued September 11, 1956. No sheets of drawings. Assigned to General Aniline & Film Corp., by Jesse Werner and Robert Steckler.

A laminated article is produced by use of glass fiber reinforcing. The article comprises sheets of fibrous glass bonded together with a copolymer of N-vinyl pyrrolidone and an allyl ester of a dibosic carboxylic acid. The copolymer contains a weight ratio of 5-20 per cent of an N-vinyl pyrrolidone and 80-95 per cent of an allyl ester of a dibasic carboxylic acid.

There are six claims and no references cited in this patent.

Glass-Reinforced Plastic Article. Patent No. 2,758,951. Filed July 23, 1953. Issued August 14, 1956. One page drawings; none reproduced. Assigned to Government of U. S. A., by James W. Case.

The invention concerns a molded plastic material formed by arranging a plurality of coated glass fibers in parallel relationship, and in one or more layers united with organic bonding material to produce a unitary, glass-reinforced plastic sheet or panel.

The process involves (1) drawing from a glass furnace successive series of molten glass fibers of varying cross-

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Research Digest

Morphology of Fractures in Polished Glass Surfaces

What conditions are necessary to bridge over or polish out fractures in a glass surface? Past experimentation has resulted in conflicting results, for example, G. T. Beilby during the course of studies on the flow of solids, demonstrated that a seemingly structureless polished surface disclosed grooves and fractures when etched with hydrofluoric acid. This effect was interpreted as the result of the removal of a flowed surface layer which covered up the furrows. F. W. Preston also found fracture networks, made visible by etching, in polished surfaces. He pointed out that these fracture networks were probably "chatter sleeks" of ultramicroscopic dimensions which had been covered over during polishing. On the other hand when J. W. French attempted to polish over minute open bubbles 1 to 2μ in diameter, he found no evidence of a bridging action.

Using a moisture-condensation method, W. C. Levengood and W. E. Fowler (*Journal of the American Ceramic Society*, January, 1957) were able to demonstrate the importance of the shape of a fracture in the bridging phenomenon and their experiments indicate that the basis of the above paradox was the considerable variation in relative shapes and sizes of the flaws polished over in the above early experiments. In the quoted work, polishing experiments were conducted on visible fractures which were literally forced closed. A modified condensation chamber was devised to study fracture growth in polished surfaces over extended periods of time. With this technique it was possible to determine the rate of fracture growth for periods up to 300 hours.

For the polishing experiments, fractures were prepared by making a cutter mark at the edge of sheet glass specimens 3/16 in. thick and then extending the fracture beyond the cut into the body of the glass. If lateral pressure was applied, e. g., by clamping the sides of the glass, the crack usually closed and disappeared from view.

When a fracture was viewed at about normal incidence in white light, a blue film was observed at the boundary between the visible high-reflecting portion of the crack and the invisible clamped segment. This blue reflection indicated constructive interference in the spectral region near 4800 a. u. The thickness of the fracture when this occurred was about $\lambda/4$, or approximately 1200 a. u. The intensity of reflection from the crack surface dropped very rapidly and in the zone receiving the greatest clamping force no reflection was observed. When there was no visible reflection the fracture thickness was about $\lambda/25$, or 200 to 300 a. u. This approximated the upper limit of the thickness or width of the cracks polished in the following experiments.

The fractures were polished with a high-speed felt wheel, saturated with rouge, which was applied normal to the crack. The depth of the polished-out region was about 2μ in every case.

After the polishing operation, the specimens were cleaned with precipitated calcium carbonate, rinsed with distilled water, and then dried. A moisture film was condensed on the surface by gentle breathing; the specimen was then covered with a small chamber to prevent rapid evaporation.

The condensation pattern shows that the clamped fracture may be detected in the surface of the specimen before polishing. (The fracture is visible as a sharp line running horizontally across the field.) The depth of this fracture was about 3 mm. and the thickness after clamping was about 300 a. u. After polishing no fracture line appears in the condensation patterns; this indicates that the fracture has been bridged over. The clamp was left on the specimen, and after about five hours the fissure began to reopen.

Attempts also were made to bridge over these fractures without clamping; in no case was there any evidence of a disappearance or polishing out of the cracks.

In some cases the clamping force was released immediately after polishing. It was surprising to observe that the fracture opened to the edge of the polished region, but did not open through the polished region. The condensation pattern disclosed that after the clamping force had been removed, the crack spread very slowly through the polished region. Several minutes generally elapsed before the crack opened to its original width.

An experiment was then performed to find out whether etching with hydrofluoric acid would uncover these polished-over fissures. The clamped polished fracture was etched at room temperature for 20 seconds in dilute hydrofluoric acid (one part 48 per cent acid to eleven parts water) and then was rinsed. A layer approximately 500 a. u. thick was removed by the acid. Etching apparently removed the polished layer and exposed the crack extending below the surface.

The polishing and etching technique was also applied to glass that had been scratched with an abrasive. A pattern of crossing fissures was made by drawing a 400-grit silicon carbide abrasive paper across the glass under a load of about 100 gm. per sq. cm. The condensation droplets in the area before polishing did not outline all the fractures because the rough surface causes the droplets to coalesce where the scratches are close together. The specimen was then etched for 20 seconds in dilute hydrofluoric acid (same concentration as above) and again a layer 500 a. u. thick was removed. Many of the crossing fissures which were covered over during the polishing were again exposed by the etching treatment.

The small breath-figure chamber was modified in design so that polished surfaces could be observed for longer periods of time. The essential elements of the modified apparatus are two chambers. After a specimen had been polished and cleaned it was placed on one chamber, and the water was gently heated until the condensation pattern formed on the test surface. The chamber, with the specimen still in position, was then placed

(*Continued on page* 157)

Current Statistical Position of Glass

Employment and Payrolls: Employment in the glass industry during December, 1956 was as follows: *Flat Glass:* A preliminary figure of 31,100 for December, 1956 indicates a decrease of 1 per cent from the adjusted 31,400 reported for November 1956. *Glass and Glassware, Pressed and Blown:* A decrease of 1.8 per cent is shown by the preliminary figure of 83,100 for December, 1956 when compared with 84,600 of November 1956. *Glass Products Made of Purchased Glass:* The preliminary figure of 16,100 for December 1956 indicates an increase of 6 per cent from the previous month's figure of 16,000.

Payrolls in the glass industry during December, 1956 were as follows: *Flat Glass:* An increase of .4 per cent is shown in the preliminary $15,740,716.40, when compared with November, 1956 adjusted $15,674,849.86. *Glass and Glassware, Pressed and Blown:* A decrease of .8 per cent is shown in the preliminary $29,672,192.94, reported for December, 1956 when compared with the previous month's adjusted $29,904,502.58 figure. *Glass Products Made of Purchased Glass*: A preliminary figure of $4,939,480 was reported for December 1956. This is an increase of .6 per cent compared with the adjusted figure of $4,908,800 of the previous month.

Glass Container Production: Based on figures released by the Bureau of Census was 11,698,000 gross during January, 1957. This represents an increase of 12.3 per cent from the previous month's production of 10,411,000 gross. During January, 1956, glass container production was 11,099,000 gross or 5.4 per cent under the January, 1957 figure.

Shipments of glass containers during January, 1957 increased 4.6 per cent to rise to 10,312,000 gross. This is an increase from December, 1956 shipments which were 9,856,000 gross. Shipments during January, 1956 were 9,817,000 gross or 5.0 per cent under January 1957.

Stocks on hand at the end of January, 1957 were 14,976,000 gross. This is 7.6 per cent above the 13,924,000 gross on hand at the end of December 1956 and 7.0 per cent higher than the 13,995,000 gross on hand at the end of January 1956.

Automatic Tumbler Production: During December 1956 was 4,915,000 dozen. This is a gain of 9.3 per cent against the December, 1955 production which was 4,498,000 dozen.

Shipments during December, 1956 rose to reach 4,865,000 dozen. This is 9.9 per cent higher than the 4,425,000 dozen shipped during December 1955. At the end of the twelve months period ending December 31, 1956, shipments have reached a total of 54,630,000 dozen which is 12.7 per cent lower than the 62,539,000 dozen shipped last year.

Table, Kitchen and Household Glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during December, 1956 reached 3,094,000 dozen. At the end of the twelve months period ending December 31, 1956 manufacturers had sold a total of 33,843,000 dozen, which was 9.4 per cent lower than the 37,360,000 dozen sold during the corresponding 1955 period.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	Jan., 1957
Food	954,000
Medicinal and Health Supplies	1,434,000
Chemical, Household and Industrial	819,000
Toiletries and Cosmetics	765,000
Beverage, Returnable	394,000
Beverage, Non-returnable	90,000
Beer, Returnable	90,000
Beer, Non-returnable	487,000
Liquor	638,000
Wine	332,000
Sub-total (Narrow)	6,003,000

Wide Mouth Containers

Food	*2,929,000
Medicinal and Health Supplies	490,000
Chemical, Household and Industrial	153,000
Toiletries and Cosmetics	215,000
Packers' Tumblers	89,000
Dairy Products	184,000
Sub-total (Wide)	4,060,000
Total Domestic	10,063,000
Export Shipments	249,000
TOTAL SHIPMENTS	10,312,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production Jan., 1957	Stocks Jan., 1957
Food: Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	7,073,000	9,812,000
	Wide Mouth	*4,625,000	*5,164,000
Beverage, Returnable		686,000	1,341,000
Beverage, Non-returnable		104,000	162,000
Beer, Returnable		190,000	357,000
Beer, Non-returnable		622,000	684,000
Liquor		719,000	1,262,000
Wine		435,000	606,000
Packers' Tumblers		80,000	123,000
Dairy Products		244,000	311,000
TOTAL		11,698,000	14,976,000

*This figure includes Fruit Jars and Jelly Glasses.

Research Digest . . .

(*Continued from page* 155)

under the microscope for observation. After completion of the examination the specimen was transferred for storage to the other chamber which contained a desiccant.

Storing in this dry atmosphere was found to delay the formation of a weathered film which would obscure or cover surface details.

Not all the fractures in the polished surfaces were observed to grow with aging. Those that did grow were of various initial lengths and were randomly scattered over the polished surface.

TABLE I

Elapsed time after polishing (hr.)	Crack length (μ)
0.1	211
2.0	287
5.0	358
21.0	404
45.0	462
93.0	477
168.0	508
248.0	528

Table 1 gives the measured lengths of a typical fracture for various ages of the polished surface. The results when plotted, show a linear relationship between crack length and the logarithm of time. In every case studied (ten different polished surfaces), the minute fractures appeared to grow in this manner. The rate of growth, or slope of these curves, varied somewhat, depending on the initial lengths of the fractures and the degree of polish.

In summation, the moisture-condensation technique was employed in the study of fractures in glass which were forced closed by applying lateral pressure. These fractures were normal to the glass surface, about 3mm. deep, and after clamping, were less than 300 a. u. wide. Polishing was found to bridge over or cover these clamped fractures. When the clamping force was released, the crack did not spread immediately through the polished region; generally, several minutes elapsed before the fracture opened to its original width.

Etching a clamped polished fracture caused it to open immediately. In this case the acid apparently removed the thin polished layer and exposed the underlying crack.

A series of crossing fractures, produced with fine abrasive paper, also was covered over by polishing. Etching in dilute hydrofluoric acid again exposed many of the fractures which had been covered.

A modified condensation chamber was devised so that polished surfaces could be examined periodically. The test specimen was stored in a dry atmosphere to prevent a weathered film and was transferred to a special condensation chamber only for examination. This technique revealed that some randomly scattered minute fractures in polished surfaces exhibit growth. The growth of these fractures was studied in detail for periods of time extending to about 300 hours. For the polished surfaces examined, a linear relationship was observed between fracture length and the logarithm of time.

Inventions and Inventors . . .

(*Continued from page* 154)

sectional areas. (2) Winding said successive series of fibers upon a receiving drum, until the number of wound layers produces a desired thickness of glass upon the drum, then removing all of the glass from the drum by a longitudinal cut through all the layers, to permit the wound glass layers to be laid out on a plane surface, in the form of a mat. (3) Applying to said glass mat a quantity of liquid filler material sufficient to unite the glass fibers into a single plastic entity by the penetration of the liquid filler into all of the spaces between successive fibers. There were four claims and the following references cited in this patent. 2,057,393, Powell, Oct. 13, 1936; 2,422,969, Johns, June 24, 1947; 2,564,882, Cubberley et al., Aug. 21, 1951; 2,565,941, Bernard, Aug. 28, 1951; 2,574,221, Modigliani, Nov. 6, 1951; 2,577,214, Slayter, Dec. 4, 1951; 2,609,320, Modigliani, Sept. 2, 1952 and 2,699,415, Nachtman, Jan. 11, 1955.

Tube and Cane Machines

Shaping Glass Tubes. Patent No. 2,754,626. Filed May 14, 1952. Issued July 17, 1956. Two pages drawings; none reproduced. George K. Porter.

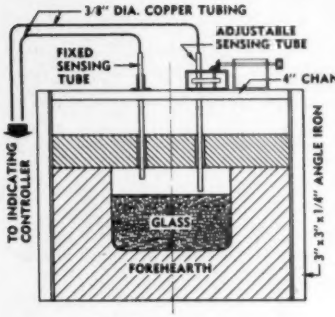
A support is provided: at least one, and preferably, a plurality of vertically disposed pending-tube-engaging mounting connections which in communications with an air evacuating system, such as a vacuum pump, is mounted on conduits each of which has a gear. All of the gears are in mesh with one driven gear, so that each tube mount is rotated, either clockwise or counterclockwise. At least one, and preferably a battery of electrical heating units is mounted on a common support, initially spaced vertically from the tube-mounting connections. Each heating unit comprises a hollow vertical coil of heavy resistance wire enclosed in suitable insulation, except for an axial vertically-extending window installed in front of at least part of the resistance coil and preferably for the full axial length of it. The turns of the resistance coil are spaced apart. Thus, the operator can observe the interior of the coils through the windows and through the spaces between the coils. Each hollow coil is vertically aligned with a respective tube-mounting element. The coils are heated by the passing alternating current of low voltage and high amperage, through the coils. The battery of heating coils is movable toward the hose couplings either manually, or by a variable timing control.

The tubing lengths, containing mandrils, are inserted axially upward into the respective tube-mounting connections. The rotation of the connections rotates the tubes and enclosed mandrils, which are then respectively threaded through the corresponding hollow coils. The evacuation pump is then started. When the heating battery has risen far enough to bring the glass into contact with the thicker end of the mandril, the shaping is completed, and the battery of heat units is withdrawn downward, clear of the now shaped tubing. The mandrils are next withdrawn, the ends of the shaped tubes are cracked off, and the tubes may then be cut and ground at the ends to the required lengths. There were 5 claims and 15 references cited in this patent.

(*Continued on page* 159)

New Equipment and Supplies

NEW GAUGE MAINTAINS GLASS LEVEL IN FURNACE



General Glass Equipment Service, 5 South Virginia Avenue, Atlantic City, N. J., has available their Auto-Level, an automatic sensitive gauge which measures, records, if desired, and maintains the glass level within a glass tank furnace to plus or minus 1/32 inch.

In operation, a tube through which a constant air supply flows, is lowered into the tank furnace near the surface of the glass which is to be controlled. As the nearness of the glass to the tube increases, a restriction to the flow of air is created causing a back pressure to occur within the sensing tube. Conversely, as the distance between the glass and the sensing tube increases, there is a lowering of the back pressure due to the rise and fall of the glass level. The variation of the back pressure in the sensing tube is magnified by the use of a differential pressure controller with an amplifying stage.

Since small amounts of air are used at very low pressures, it is possible to locate the sensing tube in the refining end of the furnace or in a feeder forehearth without danger of any cooling effect.

A second tube installed above the glass level is used to compensate for any change in ambient pressure. By controlling the batch charger motor it is possible to secure a simple on-off system to control the glass level. Proportional or time delay control of batch charging is also possible if desired.

LIQUID-GAS SEPARATION DEVICE

Selas Corporation of America, Dresher, Pennsylvania announces the Liqui-Jector, a liquid-gas separation device for the removal of entrained liquids and solids from air, gas and steam systems. It is available in 12 standard sizes and operates by phase separation; trapping solids, and passing liquid in one direction and gas in another, without interrupting the flow through the line. In addition to air and steam, such gases as hydrogen, oxygen, nitrogen, argon, propane, butane and generated atmospheres are cleaned and dried.

The Liqui-Jectors are now available in three standard models: Series A for volumes up to 100 scfm gas at 150 psig; Series B for volumes up to 7,000 scfm gas at 200 psig; and Series C for conditions where unusually large volumes of condensate are encountered. The company will continue to build especially-engineered units, as in the past, to provide operation under special conditions, for unusual applications, or where extremely high flow or low pressure drop is required.

NEW DRUM-TYPE MULTIPLE INDICATOR

The Bristol Company, Waterbury, Connecticut has just announced a new drum-type precision indicator for quick readings of variables at remote points.

This indicator uses the company's standard Dynamaster electronic instrument components. It is equipped with numbered push button switches on the front of the case, and can scan up to 48 remote points quickly. The revolving drum-type scale has a calibrated length of over 26 inches. Full-scale travel takes place in 4½ seconds.

Offered primarily in Resistance Thermometer and Pyrometer models, it can also be supplied for measuring other variables.

More details are available in bulletin P1245A, available on request.

AIR GAGING INSTRUMENT

Air Gage Division, Dearborn Gage Company, Dearborn, Michigan announces a new standard line of multiple-column air gaging instruments which rapidly check a number of close-tolerance surfaces at the same time.

According to the manufacturer, the multiple-column arrangement of this equipment permits the accurate and simultaneous measurement of up to eight separate dimensions, with gage response within five-tenths of a second.

Major features of this new Dearborn-aire line include a new, self-cleaning pressure system, complete linearity over the full scale, interchangeable component parts, two-step amplification conversion, and zero-centered scale permitting tolerances to be read at plus or minus from the nominal dimensions.

SHUT-OFF SOLENOID VALVE

Automatic Switch Co., 391 Lakeside Avenue, Orange, N. J. is offering a new two-way solenoid valve for cooling applications using liquid CO_2. These shut-off valves were designed and developed by the company in response to CO_2 manufacturers' requests for a valve that would automatically control the discharge of liquid CO_2. Two types of construction are available: direct injection and remote injection. The valves have stainless steel, angle type bar stock bodies and teflon discs for tight shut-off on pressures to 1,000 psi. Valves mount in any position without affecting operation.

CATALOGS RECEIVED

Bausch & Lomb Optical Company, 635 St. Paul Street, Rochester, N. Y. has announced two publications. One, Booklet D-1059, "Industrial Optical Aids", contains information on inexpensive precision optical instruments and ways to use them. Items discussed include magnifiers, microscopes, wide field tubes, macroscopes and comparators. The other Booklet, L-199, is titled "Opportunities Unlimited", cites the key role played by optical research and development programs. Specific sections outline the opportunities which the firm offers to specialists in mathematics, physics, ceramics, chemistry, and metallurgy and to mechanical, electronic, systems, ceramic chemical and industrial engineers.

Brooke Engineering Company, Inc., 4517 Wayne Avenue, Philadelphia, Pa. offers a bulletin describing its new type EHA smoke indicator and indicator-recorders. The indicator unit is operated by a photo electric cell mounted at the boiler outlet and the smoke density is translated to a meter reading at a remote location without any time lag whatsoever. A hermetically sealed time delay contact is provided to sound an audible alarm, if desired, a few seconds after the red light comes on warning the fireman of excessive smoke. This time delay prevents occasional puffs of smoke from sounding the alarm. Two types of indicator-recorders are also described: The violation indicator-recorder records the length of time the smoke has exceeded the set density. The density indicator-recorder continuously records the degree of density from clear to black. Ask for Bulletin 30 direct from the company.

J. H. France Refractories Company, 1944 Francis Road, Snow Shoe, Pa. has issued an 8-page bulletin on the company's complete line of firebrick, high alumina and Corindon Brick. Seven special technical data tables, pyrometric cone equivalents, fushion points, hot load strengths, linear change, panel spalling loss, porosity and average chemical composition of the company's Medal, Rockspar, France Non Spall, Lehigh, Center, Case, Francite 70% and Franco 60% High Alumina Brick. A section is also devoted to the company's Corindon brick. In addition over 150 recommendations are listed for the complete line of brick.

Inventions and Inventors . . .
(*Continued from page* 157)

Miscellaneous Processes

Bulb Washing And Reflector Coating. Patent No. 2,730,068. Filed March 14, 1952. Issued January 10, 1956. Six sheets of drawings; none reproduced. Assigned to General Electric Company by K. W. Reynolds and J. A. Billson.

The invention relates in general to an apparatus for applying metallic reflector coatings to the interior surface of glass lamp bulbs or similar hollow glass articles.

In the general operation of the apparatus, the glass lamp bulbs are loaded one by one in a neck-down position, by a combination loading and transfer device, into successive heads of an intermittently indexing prewashing turret, which then carries the bulbs through a series of stations at which they are first interiorly washed by injecting a stream of a suitable cleaning solution such as deionized water. The excess water is then removed from the interior of the bulb by injection of air jets, the bulbs are then externally heated to vaporize the moisture remaining within the bulbs, followed by removal of the vaporized moisture by injection of heated air jets into the bulbs. The bulbs are then intensively externally heated in an oven to a temperature in the neighborhood of 300°C. in preparation for the subsequent evacuation of the bulbs and application of the reflector coating thereto. The prewashed bulbs are then automatically transferred by the transfer device to successive heads of an intermittently indexing second or reflector-coating turret, which then carries the bulbs through a series of stations at which they are progressively evacuated and then a reflector coating is vaporized onto the interior surface thereof.

A machine combines the operations of cleaning the bulb and applying a reflector coating thereto so that these operations are greatly simplified and concentrated at one location in the factory, and the amount of handling of the bulb reduced to a considerable degree, thereby resulting in a much more efficient and simplified manufacturing procedure. Also, the heating of the bulbs on the prewash turret to an elevated temperature, preferably over 100°C., but below the softening point of the bulb glass, serves to drive out all the moisture on the internal surface of the bulb and to materially reduce the amount of air in the bulb, thereby appreciably shortening the time required for the subsequent evacuation of the bulb on the reflector coating turret.

There were seven claims and eleven references cited in this patent.

Method Of Sizing Mineral Fibers. Patent No. 2,723,208. Filed September 13, 1951. Issued November 8, 1955. Assigned to Owens-Corning Fiberglas Corporation by A. R. Morrison.

This invention relates to the treatment of glass fibers and it is an object of this invention to produce a new and improved sized glass fiber.

The following method has been successful:

Size composition:

1.5 per cent by weight polyamide cationic suspensoid, 35 per cent solids (General Mills A-200)

3.5 per cent by weight butadiene-acrylonitrile copolymer (25 parts acrylonitrile—75 parts butadiene) (45 per cent solids)

0.2 per cent by weight lubricant (cetyl dimethyl benzyl ammonium chloride)

Application onto the glass fibers was made by a roll applicator in forming. About 2.5 per cent by weight solids based upon the weight of glass fibers was deposited. The wet strands had excellent twisting qualities and the twisting characteristics after drying at 130°F. for 48 hours or fusing by exposure to 250°F. for two hours, remained very good. The winding qualities of the wet strand were not as good as the dried strand and the final fused strand had excellent winding characteristics.

There were 9 claims and the following references cited in this patent: 2,518,148, Jordan, Aug. 8, 1940; 2,424,588, Sparks et al., July 29, 1947; 2,446,119, White et al., July 27, 1948; 2,550,465, Gorski, Apr. 24, 1951; 2,563,289, Steinman, Aug. 7, 1951; 2,633,432, Kenneway, Mar. 31, 1953, and 555,481, Great Britain, Aug. 25, 1943, and Polyamide Resin Suspensoids, General Mills, Inc., October 20, 1954 (only p.6 relied on).

Coating Bulbs. Patent No. 2,716,620. Filed January 26, 1952. Issued August 30, 1955. Two sheets of drawings; none reproduced. Assigned to Westinghouse Electric Corp., by J. H. Green, and S. A. Lopenski.

This invention relates to the application of enamel to incandescent electric lamp bulbs. A machine of the indexing type is used and consists of a horizontal conveyor and a simple bulb holder. The ceramic enamel is sprayed vertically downward on the bulbs and the surplus coating is removed from the bottom edges by means of an internal water spray. The latter operation is necessary to avoid interference with subsequent butt-sealing of the bulbs. The coated bulbs are dried, fired and cooled in a gradual but expeditious manner by using electric strip heaters and a simple refractory burner. The cooling is effected first by still air as the bulbs are rotated and finally by means of a fan prior to removal from the machine in order to speed up the cooling operation. It was found that lead glass bulbs could be used with lime frit enamels as well as lead frit enamels.

There were 10 claims and the following references cited in this patent: 1,589,956, Hageman et al., June 22, 1926; 1,655,290, Phelps et al., Jan. 3, 1928; 2,141,630, Westin, Dec. 27, 1938; 2,229,631, Baker et al., Jan. 28, 1941; 2,270,132, Malloy et al., Jan. 13, 1942; 2,342,307, Smith, Feb. 22, 1944; 2,420,620, Remington et al., May 13, 1947, and 2,426,391, Emerson, Aug. 26, 1947.

Method Of Treating Glass With Silane Triol. Patent No. 2,723,211. Filed April 13, 1953. Issued November 8, 1955. Assigned to Cowles Chemical Company by C. W. MacMullen and A. Marzocchi.

This invention is concerned generally with the application of organosilicon coatings to various materials to render them water-repllent. It is particularly useful in connection with the application of organosilicon coatings to glass fibers either before or after weaving to confer certain desirable properties such as water repellency, resin adhesion and abrasion resistance on the fibers and cloth woven therefrom.

In general, the solutions are prepared by causing an organotrihalosilane to react with an aqueous alkali con-

taining say 5 per cent to 25 per cent by weight of alkali metal hydroxide and maintaining the concentration of alkali at a sufficiently high value to provide a stable solution of the alkaline hydrolysis products of the organotrihalosilane. The solutions of organosilicon compounds thus prepared exhibit excellent wetting properties and hence spread rapidly over the glass surfaces to be treated and rapidly penetrate a woven mass of fibres. Such aqueous solutions are more convenient for use in treating fibres and fabrics than are organic solvent solutions of organosilicon compounds that have been previously proposed.

The solutions may be prepared as follows:

An aqueous alkaline solution containing about 10 per cent by weight of sodium hydroxide was prepared by diluting 707 grams of aqueous 42 per cent caustic soda with 2683 grams of water in a stainless steel beaker. To this caustic soda solution was added 192.5 grams of vinyl trichlorosilane in a thin stream with stirring. The mixture was stirred for one hour to produce a solution of sodium salts comprising the alkaline hydrolysis products of vinyl trichlorosilane.

The aqueous alkaline solution of the hydrolysis products as thus prepared was added to an aqueous acid in ratio of one part by weight of the alkaline solution to four parts of acid, (HCl) the concentration of acid being so selected as to give the mixed bath a pH of about 4.

There were 11 claims and the following references were cited in this patent. 2,306,222, Patnode, Dec. 22, 1942; 2,439,689, Hyde, Apr. 13, 1948; 2,507,200 Elliott, May 9, 1950; 2,531,571, Hyde, Nov. 28, 1950; 2,563,288, Steinman, Aug. 7, 1951; 2,568,384, Cheronis, Sept. 18, 1951; 2,587,636, MacMullen, Mar. 4, 1952, and 2,646,373, MacMullen, July 21, 1953.

Coloring Glass Fabrics with Resinous Coating. Patent No. 2,722,488. Filed August 16, 1952. Issued November 1, 1955. One sheet of drawings; none reproduced. Assigned to General Aniline and Film Corporation by Charles L. Lawsberg.

This invention relates to processes for coloring glass fabrics with vat dyes, and more particularly to the coating of said fabrics with a water-insoluble resinous interreaction product of a water-soluble resinous polyhydroxy compound and a water-soluble interpolymer of maleic anhydride with a member of the group consisting of vinyl methyl ether, vinyl ethyl ether, and vinyl acetate, and applying thereto a vat dye in the ordinary keto form or as the alkali salt of the leuco (anthrol) form followed by conversion to the keto form. Preferably, the vat dye is applied after formation of the cured resinous coating on the fabric; however, if desired, the keto form may be applied together with the resin-forming materials, whereby the resin application and dyeing are carried out in one step. The invention also relates to the resulting dyed glass fabrics.

There were 14 claims and the following references were cited in this patent: 2,259,225, Kienle, Oct. 14, 1941; 2,273,040, Iler, Feb. 17, 1942; 2,407,483, Ebaugh, Sept. 10, 1946; 2,448,515, Carroll, Sept. 7, 1948; 2,469,409, Powers et al., May 10, 1949; 2,609,350, Spatt, Sept. 2,

(*Continued on page* 164)

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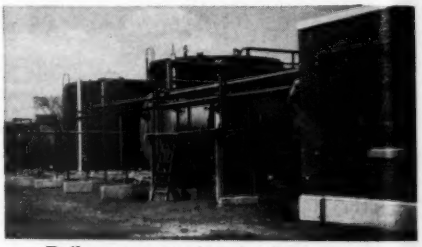

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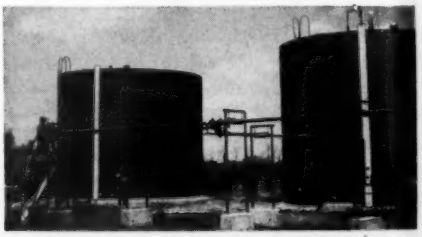

Bulk storage tanks with interconnecting, unloading and transfer lines.

Shutdowns due to curtailment of natural gas have proved costly to many manufacturers in the past.

On the other hand, glass melting plants where precautionary wisdom has been exercised are no longer plagued with fuel supply problems.

★ TECO can design the complete system from bulk unloading station, up to the oil burner on the furnace.

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Application of Data . . .
(*Continued from page* 151)

is determined almost entirely by the viscosity of the surface layer. At the end of the dwell (Curve 2) the apparent surface viscosity is Log 7.15, while the center value is Log 3.6; the surface is less mobile than the center, at this instant, by a factor of 3500. After one second of reheat (Curve 3), the surface has increased in temperature such that the viscosity is approximately Log 5.8; at this instant, therefore, the surface is roughly 20 times as mobile as at the end of dwell. In addition, the center has cooled slightly to become more viscous during the one second of reheat, with the result that the surface is only 100 times as viscous as the center.

At 3 seconds of after-cooling (Curve 4) both the surface and the center have increased in viscosity. The surface is still at least 5 times as mobile as it was at end of dwell, but the ratio of surface to center viscosities has increased to about 200. One sees, therefore, that in the present example, the glass is in optimum condition for ease of blowing at approximately one second after the end of the pressing action. In general, of course, the most favorable reheat time will vary with the thickness of the section and the severity of cooling imparted by the blank mold.

CONCLUSION

The program of research discussed herein is based on the premise that the mechanical and thermal transients occurring in glass during forming processes must be measured experimentally. The intricacy of these processes, and the present inadequacy of the theory on non-steady-state heat transfer in glass, make it doubtful if such problems will be solved by theoretical calculation in the foreseeable future.

Information derived from this program is now in practical use in machine production and in the development of new machines. Research is continuing on improvement and further use of existing methods and the development of new instrumentation, particularly for measurement of temperatures at or near the surfaces of glass and mold metals.

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(3) I. I. Kitaigorodsky and N. W. Solomin, "Rate of Setting of Glass During Working", *Jour. Soc. Glass Tech.*, *18*, 72 323-35, (1934).
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Directly and indirectly, Calumite is helping manufacturers of amber ware to increase their profits.

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VICTOR REMINGTON NAMED DRAKENFELD DIRECTOR

Victor H. Remington, manager of the Washington, Pa., plant of B. F. Drakenfeld & Company, Inc., has been made a director of the company.

Mr. Remington became vice president in 1954. He has been with the Drakenfeld company since 1928.

An authority in the field of glass colors research and development, Mr. Remington was manager of the company's Glass Colors Division for many years. He has written a number of technical papers for glass and ceramics publications, and is a member of the American Ceramic Society and the American Association for the Advancement of Science.

• The Chas. Taylor Sons Co., manufacturers of special refractories, a subsidiary of National Lead Company, announces the opening of a new district sales office at 5845 Greenbrier Road, Atlanta, Georgia. Manager of the office is Stafford T. Lantz, a field engineer for Taylor with 12 years' experience.

SELAS FORMS EUROPEAN SUBSIDIARY

The formation of a European subsidiary known as Selas Corporation of America, European Division S.A., with headquarters in Geneva, Switzerland, was announced by Frederic O. Hess, president, Selas Corporation of America, Dresher, Pa.

The new firm, serving industries throughout Western Europe, will coordinate engineering and administration between licensees and the Selas home office in Dresher. Selas manufactures equipment for industrial heat and fluid processing of materials.

Heading the Swiss Selas Corporation is W. Jack Hofmann, General Manager, with A. E. Baltus, who has been general European representative for Selas the past seven years, as Sales Manager.

PARIS SYMPOSIUM TO BE PUBLISHED

The Volume of the Symposium on the Fining of Glass held in Paris in June 1955 was due to be published in February 1957.

This volume of approx. 600 pp and 249 figures contains the full texts of the thirty papers presented. They are printed in the original languages, English, French and German. The book also contains the reports of the working groups on Methods, Theories, Technology and the final report.

All pertinent information can be obtained from the Secretary of the Union Scientifique Continentale du Verre, 24, rue Dourlet, Charleroi. (Belgium).

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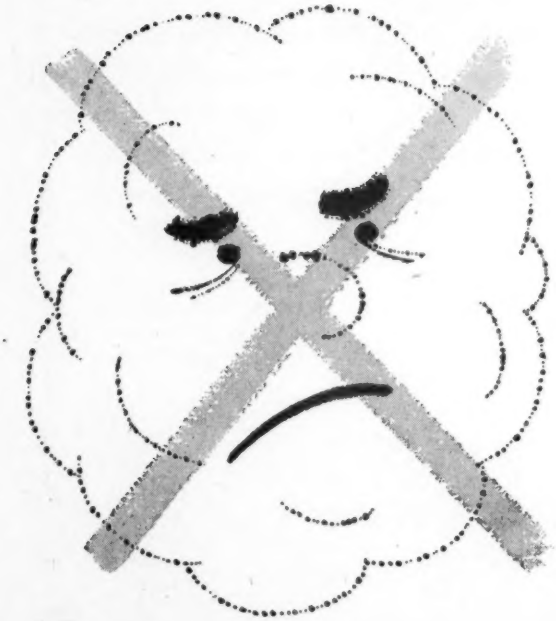

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DU PONT GLASS COLORS

Milestones in Glass Progress

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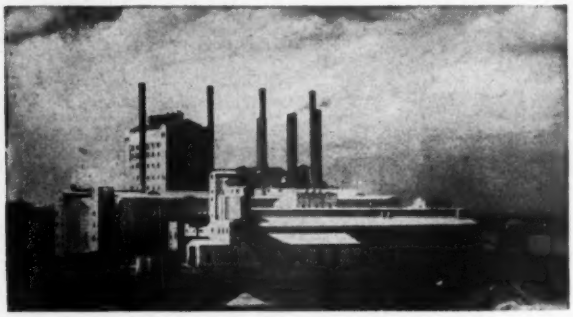
1570 This 16th century Venetian glass bottle is lavishly trimmed in gold and enamel, studded with false pearls. These pearl imitations were made from tubes of glass, the ends of which were blown into ball or pear shapes, then colored. Bottles similarly decorated were popular as marriage or betrothal gifts.



1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation, was founded by Captain J. B. Ford to supply Soda Ash to the glass industry; part of Wyandotte's modern Soda Ash facilities is shown above. Wyandotte has literally grown up with glass. Today, as in the past, it is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

Wyandotte CHEMICALS

Michigan Alkali Division, Wyandotte Chemicals Corporation
Wyandotte, Michigan • Offices in principal cities

Founded by a Glassmaker to Serve the Glass Industry

Inventions and Inventors . . .

(*Continued from page* 160)

1952; 2,645,553; Lawsberg, July 14, 1953; 559,329, Great Britain, Feb. 15, 1944, and 650,682, Great Britain, Feb. 28, 1951.

Cellulated Material. Patent No. 2,736,142. Filed June 3, 1953. Issued Feb. 28, 1956. 6 pages drawings; none reproduced. Assigned Pittsburgh Corning Corp. by K. Baumler and W. D. Ford.

The present invention relates to the manufacture of cellular vitreous products and has particular relation to the manufacture of cellular vitreous products such as cellular glass and cellular silica from suitable pulverulent batch materials.

One of the problems involved in the production of a cellular vitreous material from a suitable pulverulent batch is concerned with the uneven sintering and cellulating of the mass to produce a nonuniformly cellulated product containing folds, voids, and other manifestations of irregular cellulation.

In accordance with the present invention, it was found that when small individual segments of batch were formed, placed a small distance apart on a graphite slab and heated, a shorter sintering time was required and uniform cellulation was obtained free from folds. It has also been found desirable to have the segments as compact as possible. For example, 112 compactly formed segments, one and a half inch square by five eighths inch thick were placed on end on a 13 x 18 inch graphite slab. The segments were arranged in eight rows of 14 each with about ¼ to ⅜ inch spacing between them. The slab and contents were then inserted in a carbon electric furnace and in 27 minutes brought up evenly to a temperature of about 3360°F., maintained at such temperature for about 9 minutes, and then allowed to cool to room temperature. A single slab of uniformly cellulated silica 4 x 13 x 18 inches in size having a density of about twelve pounds per cubic foot was formed from such treatment.

There were 8 claims and the following references were cited in this patent: 1,118,441, Porter, Nov. 24, 1914; 1,543,770, Hilbert, June 30, 1925; 2,123,536, Long, July 12, 1938, and 2,578,110, Tooley, Dec. 11, 1951.

Decalcomania Process for Making Cathode-Ray Tube Screen. Patent No. 2,734,013. Filed March 11, 1954. Issued February 7, 1956. One page drawings; none reproduced. Assigned to Avco Manufacturing Corp. by William H. Myers.

The invention comprises a process wherein strips, dots, or areas of either black and white phosphor mixtures or color phosphors are printed on an organic type base having a paper, plastic or other suitable backing with a low temperature coefficient of expansion. The resulting decalcomania is then used to apply the phosphors to the cathode-ray tube screen after which the backing surface is removed. If desired, an aluminum coating may be applied on the base film before the backing is secured, during fabrication of the decalcomania, or after the backing is removed as a step in the screen fabricating process.

This process not only provides an accurate color phosphor arrangement, but also provides a base upon

(*Continued on page* 170)

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PITTSBURGH PLATE NAMES FISHER TO NEW POSITION

Appointment of John M. Fisher to the newly-created position of manager of manufacturing services for Pittsburgh Plate Glass Company's Glass Division has been announced by R. V. Reisgen, vice president in charge of glass manufacturing.

In his new position Mr. Fisher will direct and coordinate the activities of methods, incentive, statistical quality control and engineering groups. Mr. Fisher will transfer to the Pittsburgh general offices from Lincoln, Illinois, where he has served as manager of the company's double-glazed insulating window manufacturing plant since 1952.

Mr. Fisher has been associated with Pittsburgh Plate since 1917 when he joined the Ford City, Pennsylvania, plate glass manufacturing plant as an engineer. He later served in supervisory capacities both at Ford City and the company's safety glass producing plant at Creighton, Pennsylvania.

H. O. Phalin, production manager for the Lincoln plant during the past four years, has been named manager succeeding Mr. Fisher.

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GCMI PACKAGING RESEARCH LAB MOVED TO LANSING, MICHIGAN

J. G. Turk

The packaging research laboratory of the Glass Container Manufacturers Institute, Inc. has been moved from Butler, Pennsylvania, to Lansing, Michigan, according to a recent announcement by Victor L. Hall, GCMI's general manager.

Now located in a completely remodeled building at 121 West South Street in Lansing, the laboratory group, which does research and development work on fiberboard boxes and packaging for the glass container industry, will continue under the direction of Dr. John G. Turk, director for the past nine years. Richard N. Maxson, chief physicist, also made the move from Butler.

The possibility of working in close cooperation with the students and faculty of Michigan State University's neighboring packaging laboratory was one of the primary reasons for the move to Lansing.

The University has appointed Dr. Turk a lecturer, and he will take active part in the activities of the University's packaging program. In the mutual interests of the two groups, two of the University's packaging students have been employed on a part-time basis by the GCMI laboratory, and it is anticipated that graduate students may also work with the laboratory on projects of interest to both groups.

The move of the GCMI packaging group to Lansing does not affect the Institute's other existent research activities, Mr. Hall stated, adding that current projects at the University of Massachusetts, the University of California, and at Preston Laboratory will be maintained as heretofore.

• J. R. LeGrand, of Erwin, Tenn., has been appointed assistant production manager of the Consolidated Feldspar Department of the Industrial Minerals Division, International Minerals and Chemical Corp.

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THE NEW HANDBOOK OF GLASS MANUFACTURE is comprised of more than 500 pages of practical reference data—tables, charts, formulae, illustrations, and text—on all phases of glass manufacture. Each section has its own table of contents, in addition to the master table. A comprehensive index provides quick reference to the contents of the entire book.

Basically, the HANDBOOK OF GLASS MANUFACTURE is intended to give those engaged in glass manufacturing operations a starting point, or point of orientation, with respect to particular problems confronting them. By becoming familiar with materials, apparatus, equipment, and principles relating to a given problem, and with points of view that have proven successful on similar problems in the past, this new Handbook should enable those who use it to get off to a better start in solving a given problem.

It is a primary working tool for plant executives, research heads, laboratory technicians, and engineers. It is complete enough to be used as a text or reference work for a course in glass technology. It can also be used effectively by glass companies as a source of reference to many of their customers and others who wish to obtain a general knowledge of glass manufacturing.

• • •

This new handbook is the product of many individuals, each one particularly qualified to handle the subject assigned to him—a truly collaborative effort. Those who have made this book possible and their subjects appear in the opposite column.

FAY V. TOOLEY, *Editor-in-Chief*

Class Compositions
Aaron K. Lyle, *Hartford-Empire Company, Div. of Emhart Mfg. Company*

Physical Properties of Glass
Donald E. Sharp and A. E. Badger, *Libbey-Owens-Ford Glass Company*

Raw Materials
Samuel R. Scholes, *New York State College of Ceramics, Alfred University*

Procurement of Materials, Supplies and Services
C. L. Rice, *Owens-Illinois Glass Company*

Batch Materials Handling and Preparation
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Instrumentation in the Glasshouse
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F. V. Tooley, *University of Illinois*; Mellen A. Knight, *Minnesota Mining & Mfg. Company*; Aaron K. Lyle, *Hartford-Empire Company, Div. of Emhart Mfg. Company*; Victor C. Swicker, *Alexander H. Kerr & Co., Inc.*; and Axel Ottoson, *Imperial Glass Corp.*

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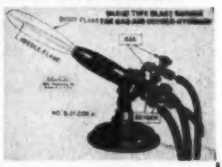

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Inventions and Inventors . . .

(*Continued from page* 164)

which an electron-permeable metallic reflecting surface may be vaporized.

There were 5 claims and the following references were cited in this patent: 2,485,607, Kasperowicz, Oct. 25, 1949; 2,665,220, De Gier, Jan. 5, 1954, and 2,681,293, Bayford et al., June 15, 1954.

Method for Continuous Mica Application for Bent Windshields. Patent No. 2,697,676. Filed September 29, 1951. Issued December 21, 1954. Four sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Lloyd V. Black and Florian V. Atkeson.

This invention pertains to the protection of glass surfaces, and specifically to protection of adjacent glass surfaces during simultaneous bending of a plurality of glass sheets or in stacking a plurality of glass sheets for transportation.

The protective material between the adjacent surfaces of the glass sheets during the bending operation must not only protect the surfaces as one sheet possibly moves relative to the other during the bending operation, but must also prevent fusion of the adjacent glass surfaces at the high temperatures necessary to effect the bending of the glass sheets. The glass sheets are handled once for applying a uniform coating of finely divided mica and no further preparation of the sheets, after bending, is necessary before inserting the plastic interlayer for the laminating operation. In such a method the coating of glass sheets can be so synchronized, with the bending and laminating operations, that straight line production can be effected from the first operation of washing the sheets prior to coating, to the last operation preparatory to loading the sheets into the autoclave for the final step of lamination. After the sheets have been bent to the desired contour they are removed from the bending mold and, without further washing, the plastic inner layer is inserted between the sheets. It has been found that such mica as remains upon the sheets and is visible before auto-claving the assembled sheets, is no longer visible after the auto-claving operation. Optical contact between the rough edges of the mica particles and the plastic inner layer eliminate "light" scattering, and the only remaining factor then would be due to refractive index differences between the mica, the plate glass and the plastic inner layer. This difference is quite small as indicated in the following tabulation:

Material:	Refractive index
Mica	1.590
Plate glass	1.522
Vinyl butyral plastic	1.477

The patent contains 6 claims and 13 references were cited.

Method and Device for Providing Electric Lamp Bulbs With an Inner Layer of Very Small Light Diffusing Particles. Patent No. 2,698,257. Filed February 10, 1951. Issued December 28, 1954. One sheet of drawings; none reproduced. Assigned to Hartford National Bank and Trust Company by Johan G. Kronouer.

This invention relates to a method of and a device for providing electric lamp bulbs with an inner layer of very small light-diffusing particles.

Use is made of a series of burners for burning ethyl silicate; thus producing smoke, over which a series of bulbs are led in a step-wise manner such that the layer formed in each bulb is built up by a plurality of devices. Irregularities of one burner do not become manifest in the final product. It is not necessary to keep all burners operative simultaneously, and more particularly, in the case of a large series of burners, it is possible to put one or more out of use for cleaning or repairs. A transport device is provided for displacing the bulbs and moves them in a step-wise manner over the burners. A very thin uniform layer of silicon dioxide is thus formed over the inside of the bulb.

The patent contains five claims and the following references were cited: 2,046,360, Baleke et al., July 7, 1936; 2,160.714, Biggs, May 30, 1939; 2,164,332, Macksoud, July 4, 1939; 2,356,136, Wampler, Aug. 22, 1944, and 2,545.896, Pipkin, Mar. 20, 1951.

Decoating Process. Patent No. 2,739,112. Filed April 8, 1952. Issued March 20, 1956. One page drawings; none reproduced. By Carl Ferguson.

This invention relates, in general, to a process for decoating or removing the surface film on various materials, and more particularly, relates to an electroionic process for removing fine films of optical coatings such as magnesium fluoride, sodium aluminum fluoride, quartz, titanium dioxide, etc. from surfaces of glass and particularly those materials used for optical elements.

The principle of the patent is based on the utilization of an electronic process including the passage of current through an electrolyte to clean or remove material from the surface of the articles.

The electrolyte 7 (shown in the example) may consist of a weak solution of an acid, as for instance, hydrochloric or sulfuric acid, and also may include chloride, sulfate, and nitrate salt solutions, inorganic base solutions, and other electrolytes. The use of a weak acid is preferred, however, since the acid results in a faster acting process which is free of pitting and obnoxious gases. A concentrated acid solution may result in a high temperature solution which results in pitting of the base material and in the formation of obnoxious acid fumes. It has been found that a weak electrolyte solution containing not more than approximately 5 per cent of a material selected from the group consisting of strongly ionizing acids, bases and salts is very satisfactory and suitable.

It should be understood that the value and kind, A. C. or D. C. of the current, passing through the electrolyte, size of the electrodes, the concentration of the electrolyte, and the spacing of the electrodes are not critical factors; and a wide variation of values of the above may be used. However, in any particular case, depending upon the thickness of the films to be used and the material which is coated, a particular value of current and a particular concentration of electrolyte would produce the best results.

A satisfactory example of the procedure is as follows:

Electrolyte 7:

Water: 600 cc.

Chemical in solution: concentrated sulfuric acid 30 cc.

Temperature of electrolyte: 150°F.

Electrodes:

Separation: 3"

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Material: copper electrodes—1½" x 3" x ¼"

Article 6:

Base material: ordinary crown glass—2" x 2" x ¼"

Coating: magnesium fluoride of 4 x 10^{-6} inches

Position: midway between electrodes

Current: 5 amp.

Voltage: 10 volts

Time of removal: 8 minutes

Condition of article after decoating: clean, smooth surface free of magnesium fluoride film.

There were 3 claims and the following references were cited: 736,669, Zoeller, Aug. 18, 1903; 1,917,039, Klein et al., July 4, 1933; 1,966,817, Haux, July 17, 1934, and 2,600,107, Gelfand et al., June 10, 1952.

DIRECTOR OF PURCHASES AT CORNING GLASS

Thomas S. Wood, Jr. has been appointed director of purchases at Corning Glass Works succeeding Russell Brittingham who will leave the company to assume the presidency of Pittsburgh Corning Corporation.

Mr. Wood joined the company's mechanical development department in 1928. He served in various production capacities in "A" Factory from 1929 to 1935 when he was named assistant manager of the company's plant at Wellsboro, Pa. From 1939 to 1941 he was plant manager at Pressware and for the next two years was assistant sales manager of the Electrical Products Division. He has been manager of the lamp sales department in that Division since 1943. Mr. Wood was graduated from Massachusetts Institute of Technology.

A. P. GREEN FIRE BRICK ACQUIRES REMMEY

W. S. Lowe, president of the A. P. Green Fire Brick Company, Mexico, Missouri, and R. H. Remmey, president of the Richard C. Remmey Son Company, Philadelphia, Pennsylvania, announced the acquisition of the Remmey Company by the Green Company. The Remmey Company devotes most of its production to the manufacture of special refractories, high temperature bonding mortar, and high alumina refractories produced from silicon carbide, mullite, zircon, and bauxite raw materials. Some fire-clay brick are also manufacured at the plant.

Remmey is now a wholly owned subsidiary of A. P. Green and will operate as a separate corporation with John G. Remmey as vice president and general manager. Robert H. Remmey, who was president, will remain with the firm as consultant. G. Bickley Remmey will be in charge of research, development, and engineering, and Francis G. Remmey will be in charge of operations. The name of the firm will remain unchanged.

The merger of Remmey Company with the A. P. Green Company unites two of the most respected and progressive organizations in the refractory industry, and gives the customers of both companies one source for a complete line of high quality refractories. The Green Company now owns and operates 14 plants . . . eight in the United States, three in Canada, two in South America, and one in England.

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90,000 sq. ft. buildings.
Approximately 9 acres land.
Heavy Industry Zoning.
Entire Property surrounded by 10' high wire fence.

PLANT # 2

Glass Furnace: Capacity to pull 60 tons product.
3 # 10 Model Lynch Glass Blowing Machines
3 Toledo Tempering Lehrs 75' long 6' wide.
Complete equipment for assembling cartons, packing, loading, etc.

LAND DESCRIPTION
614' frontage on Mt. Read Blvd., 1300' depth.
B & O Spur Track on Property.
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Approximately 19 acres land.
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